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Aggregate and Soil Proficiency Sample Testing Program for 2013

MERO-048

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Abstract	The Materials Engineering and Research Office, Soils and Aggregates Section, conducts a proficiency sample testing program for aggregate and soil materials each year to provide a means for participating laboratories to see if they are performing satisfactorily. We also conduct a sample testing program for the tests related to Superpave consensus properties of aggregates. This is conducted along with our annual Aggregate and Soil Proficiency Sample Testing Program. The laboratories are asked to perform a number of different tests on pairs of samples that have been prepared and randomly selected at the MTO Laboratory. The samples are delivered to the participating laboratories starting in June, and they report their results starting in early August. A preliminary report issued in the second week of September allows the laboratories to examine their procedures or equipment and correct any problems that may have occurred. This is the final report for both the Aggregate and Soil Proficiency Samples and Superpave Consensus Property Testing for 2013. This year, two hundred and thirty-three participants from the private and public sector participated in the Aggregate and Soil Proficiency Sample Testing Program. Sixty-seven laboratories from the private sector and MTO Downsview laboratory reported results for all four of the Superpave consensus property tests. Results of the aggregate and soil tests from the 2013 program are found to be consistent with the results reported in the last three years, but, in majority of the tests, the multi-laboratory variations show noticeable improvements over the ASTM, AASHTO or MTO precision estimates where available. Although there is improvement in the multi-laboratory variations, strong laboratory biases still remain in few of the aggregate tests, and all of the soil and Superpave test procedures. We expect that the mandatory Laboratory Quality System implemented by CCIL and their lab inspection process will bring about improvements in multi-laboratory variations.
Key Words	Aggregate, consensus property, correlation, laboratory, proficiency testing, soil, Superpave
Distribution	Unrestricted technical audience.

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March 2014

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Executive Summary

The Soils and Aggregates Section of the Materials Engineering and Research Office runs an annual proficiency sample testing program for aggregate and soil tests. This program provides a means for participating laboratories to see if they are performing satisfactorily. The laboratories are asked to perform a number of different tests on randomly selected pairs of samples that have been prepared by the MTO Soils and Aggregates Laboratory. The samples are delivered to the participating laboratories starting in June and the laboratories are required to report their results by the second week of August. A preliminary report issued in early September gives feedback to the participants while they are still operational in the current year. This allows them to examine their procedures or equipment and correct any problems that may exist. A final report is issued after analysis of the data has been completed.

This is the final report for the 2013 MTO Aggregate and Soil Proficiency Sample Testing and the Superpave Aggregate Consensus Property Testing Programs. Proficiency test samples in duplicates were shipped to two hundred and thirty-eight private and public sector laboratories. Two hundred and thirty-three of the laboratories that requested samples submitted test results in 2013. Of these, one hundred and fifty-five were aggregate producers' and road builders' Quality Control (QC) laboratories. The remainder were engineering testing consultants' and owners' laboratories. Participation in this program is mandatory for laboratories conducting quality assurance (QA) and referee testing work for MTO contracts. However, participation is optional for laboratories that do quality control (QC) testing for contractors. In general, contractor and supplier laboratories are conducting particle size analysis, wash pass 75 μm, percent crushed particles, percent asphalt coated particles, percent flat and elongated and density tests for granular base and sub-base aggregates.

In 2013, seventy-four laboratories reported results for one or more of the tests related to Superpave aggregate consensus properties. The laboratories that participate in this program conduct uncompacted void content of fine aggregate, sand equivalent value of fine aggregate, percent of fractured particles in coarse aggregate, and percent flat particles, elongated particles, or flat and elongated particles in coarse aggregate tests, in accordance with the ASTM/AASHTO test methods.

Reports to individual laboratories contain ratings for each test method, which are based on the standardized deviate for that test (i.e. a rating of 5 for data within 1.0 standard deviation of the mean, a rating of 0 for data 3.0 or more standard deviations from the mean). Ratings of each test method are also used to calculate an overall laboratory rating for each category of tests. This rating system has acted as an incentive for laboratories to improve their performance. The rating is also used as a guide by MTO to select laboratories for its quality assurance testing and for qualifying referee laboratories.

Results of the aggregate and soil tests from the 2013 program are found to be consistent with the results from previous years and, in majority of these tests, the multi-laboratory variations show noticeable improvements over the precision estimates published by AASHTO, MTO, or ASTM. Particularly, sieve analysis of coarse aggregates, Los Angeles abrasion, relative density and absorption (coarse and fine), percent crushed particles of coarse aggregates, Micro-Deval abrasion of coarse and fine aggregates, amount of asphalt coated particles, and moisture density relationship (one-point Proctor) show improvements over the precision estimates published by ASTM or MTO. Although the precision of most of the aggregate test methods compares favourably in relation to the results of previous studies and the precision estimates where available, strong laboratory biases still remain in few of the aggregate test methods. The variations in soil test results show improvement and are lower than the values reported in the previous three years of study, but the scatter plots of all three soil tests show a strong laboratory bias.

The results of Superpave consensus property tests from the 2013 program also compare favourably with the past performance of the laboratories. The variations of two of the tests in the program were found to be consistent with that of the values reported in the past three years and the values published in ASTM precision statements. The scatter diagrams for all four of the Superpave tests show strong laboratory biases.

The Soils and Aggregates Section continues to carry out the inspection of laboratories providing soil testing services to the ministry. This inspection is being done at the request of laboratories. The laboratories that are inspected and accepted by MTO must request a re-inspection if a technician who demonstrated the tests during inspection is no longer available or there has been any change in the equipment. To date, forty-nine laboratories have been inspected. Thirty-four of these laboratories are on the MTO Vendors List to do testing of soils for MTO work.

1. Introduction

This is the final report of the 2013 interlaboratory testing program organized by MTO for aggregate and soil test methods. It is primarily intended to provide a means for laboratories used by MTO to see if they are performing satisfactorily and to qualify these laboratories to perform quality assurance and referee testing for MTO contracts[1]. The design of the testing program is based on procedures for determining the precision and variability of test methods. Interested readers should refer to ASTM C670[2], C802[3], E177[4], and E178[5] for further information on interlaboratory testing programs.

Proficiency test samples were distributed to two hundred and thirty-eight participants from the private and public sector laboratories. A total of two hundred and thirty-three laboratories reported results for the Aggregate and Soil Proficiency Sample Testing Program conducted in the summer of 2013. The participants were also asked to submit results for Superpave aggregate consensus property tests, if they were equipped to perform those tests. Sixty-eight laboratories submitted results for all of the tests related to the consensus properties. Participants in both testing programs included the MTO laboratory in Downsview, the remainder being from the private sector (contractors, aggregate producers, and engineering consultants), and municipalities. Samples were delivered to laboratories in early June. A preliminary report was issued to the participants in early September.

Reports to individual laboratories contain ratings for each test method, which are based on the standardized deviate for that test (i.e. a rating of 5 for data within 1.0 standard deviation of the mean, a rating of 0 for data 3.0 or more standard deviations from the mean). Ratings of each test method are also used to calculate an overall laboratory rating. This rating system has acted as an incentive for laboratories to improve their performance.

The computer program that was developed by MTO to handle the computation and presentation of test data has two statistical methods, namely the Critical Value Method recommended in Section 4 of ASTM E178 and the Iterative (Jackknife) Technique recommended by Manchester (1979), to detect outlying observations or outliers in a set of data. For details of the program, refer to the User's Manual (report MERO-013) by Vasavithasan and Rutter, 2004. A number of statistical methods are available to test the hypothesis that the suspect observations are not outliers. MTO study often follows the Critical Value Method to remove outliers. However, the Jackknife method is used where the strict application of the critical value method tends to include extraneous results that may not stand the best chance of representing the testing performed in conformance with each of the test methods. The critical value method and iterative techniques are based on two different

1 Laboratories must also be inspected and recognized by the Canadian Council of Independent Laboratories (CCIL).
2 ASTM C670 Practice for Preparing Precision and Bias Statements for Test Methods of Construction Materials.
3 ASTM C802 Practice for Conducting an Inter-laboratory Test Program to Determine the Precision of Test Methods of Construction Materials.
4 ASTM E177 Practice for Use of Terms Precision and Bias in ASTM Test Methods.
5 ASTM E178 Practice for Dealing with Outlying Observations.

statistical approaches. As a result, the confidence intervals yielded by these two methods differ widely depending on the number of observations (number of laboratories participating in a particular test method) and the distribution of data. In the case of Iterative Technique, test results that fall beyond 2.8 times the standard deviation from the mean may be identified as outliers depending on the number of observations and distribution of data.

The critical value used in this study is that value of the sample criterion, which would be exceeded by chance with some specified probability (significance level) on the assumption that all observations in the sample come from the same normally distributed population. The critical values provided in ASTM E178, Table 1 are limited to 147 observations, but over 200 laboratories participate in our annual testing program. The critical values that are being used for the MTO study were calculated at five percent significance level (Grubbs' test) based on Grubbs' (1969 and 1972) recommendations for identifying outliers.

2. Test Results

2.1 TABLE OF TEST RESULTS

Each participant receives an individual summary of results for their laboratory. An example of a typical report is shown in Tables 1, 2, 3, and 4. Each Table of Results identifies the laboratory by number and compares the laboratory's data with the means obtained after statistical analysis of the data received from all laboratories. The identity of the laboratories is kept confidential.

Column 1 gives the test method as designated in the MTO Laboratory Testing Manual.

Columns 2 and 3 show the test data submitted by the laboratory for a pair of samples.

Columns 4 and 5 show the mean (average) test value for each sample after removal of outliers and/or invalid test results from the data set for all laboratories performing the test.

Columns 6 and 7 list the standardized deviate for each test result. The standardized deviate is used to show how the individual test results compare to the mean. It is obtained by subtracting the mean of all data ($\overline{X}$) from the actual test result reported by the laboratory (X_i) and dividing by the standard deviation (s). That is:

$$\text{Standardized Deviate} = \frac{\left(X_i - \overline{X}\right)}{s}$$

If the test result is less than the mean, the standardized deviate is negative and, if the test result is greater than the mean, the standardized deviate is positive. In brief, the standardized deviate tells us how many standard deviations the test result is away from the mean.

Columns 8 and 9 list the test method ratings, which are similar to the standardized deviate, but are in a simple numeric form. Ratings are determined as follows:

Rating 5 - data within 1.0 standard deviation of the mean.
Rating 4 - data within 1.5 standard deviations of the mean.
Rating 3 - data within 2.0 standard deviations of the mean.
Rating 2 - data within 2.5 standard deviations of the mean.
Rating 1 - data within 3.0 standard deviations of the mean.
Rating 0 - data 3.0 or more standard deviations from the mean or data considered to be outlying by other methods.

A negative sign simply indicates a result that is smaller than the mean. If one of the paired test results for a given test is excluded based on the outlier criteria, the other test result is still subjected to the statistical analysis and is only excluded if it also fails to meet the criteria.

An outlying observation is one that appears to deviate markedly from the sample population. It may be merely an extreme manifestation of the random variability inherent in the data, or may be the result of gross deviation from the prescribed experimental procedure, calculation

errors, or errors in reporting data. The outlier criteria employed for exclusion of test results from the analysis will depend on the distribution of data and the number of participants in a test. The iterative technique is one of the methods employed in this study for the selection of outliers, and is used where the strict application of critical value method tends to include the data that does not belong to the population. In the critical value method, the standardized deviate of a lab result is compared with the critical value corresponding to the number of participants in that particular test, for rejecting an outlier. The critical value is greater than 3 when the number of participants in a particular test method is 30 or more. For this reason, results with more than 3 standardized deviates may not have been identified as an outlier unless it is higher than the critical value, but a zero rating is nevertheless assigned for the test result in question. For example, if the computed standardized deviate for a lab result is 3.236 and the critical value corresponding to the number of participants in that particular test is 3.427, the lab will not be identified as an outlier but a zero rating will be assigned.

Significance need not necessarily be attached to a single low rating. However, a continuing tendency to get low ratings on several pairs of samples or on a series of tests from one procedure (e.g. sieve analysis) should lead a laboratory to re-examine its equipment and test procedure. A laboratory that reports data for a specific test consistently lower or higher than the mean over a number of test periods also needs to re-examine their test procedure, because this is evidence of a systematic bias in how the laboratory conducts the procedure. Any computer program that is used by a laboratory to calculate test results should be verified as part of this examination.

2.2 SCATTER DIAGRAMS

Youden scatter diagrams are supplied with this report (see Appendices D1 and D2). A laboratory can locate itself on the diagrams by plotting its test value for the first sample (1.13) on the horizontal axis, against its test value for the second sample (2.13) on the vertical axis. The horizontal and vertical axes are of equal length and are scaled to give the most informative display of the plotted points. In some cases, the outlying results plot outside the boundaries of the diagram. If the results from two or more laboratories happen to coincide, a single point is plotted.

Below each scatter diagram, the test number and title are given, followed by a table of statistical calculations for both samples. Here the mean, median, and standard deviation for each sample are given. The number of laboratories reporting valid data and the laboratories eliminated by statistical analysis are also listed.

The vertical and horizontal crosshairs on the plots represent the mean values for all the valid results on the first sample (1.13) and the second sample (2.13), respectively. These lines divide the diagram into four quadrants, numbered 1 through 4, beginning in the upper right-hand quadrant and continuing clockwise. In an ideal situation where only random errors occur, the points are expected to be equally numerous in all quadrants and will form a circular distribution. This follows because plus and minus errors should be equally likely. Often, however, the points tend to concentrate in quadrants 1 and 3 on the diagram. This occurs because laboratories tend to get high or low results on both samples. This gives

evidence of individual laboratory biases. As the tendency to laboratory bias increases, the departure from the expected circular distribution of points towards a linear distribution from quadrant 1 to 3 occurs. Such a distribution of points indicates systematic variation. Figure 1 gives examples of scatter diagrams.

Table 1. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47 DATE PREPARED: November 15, 2013

COARSE AGGREGATE REFERENCE SAMPLES 1.13 & 2.13

TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.13	2.13	1	2	1	2	1	2
LS-601 Wash Pass 75 µm (Coarse Agg.)	1.220	1.300	1.216	1.223	0.015	0.301	5	5
LS-602 – Coarse Aggregate								
Percent Passing 19.0 mm	93.600	96.000	95.759	95.779	-2.587	0.279	-1	5
Percent Passing 16.0 mm	**86.100**	88.400	**90.016**	89.861	***-3.526**	-1.194	**0**	-4
Percent Passing 13.2 mm	80.500	82.400	83.755	83.579	-2.144	-0.763	-2	-5
Percent Passing 9.5 mm	69.300	70.900	72.155	71.848	-1.789	-0.561	-3	-5
Percent Passing 4.75 mm	52.720	53.990	54.793	54.217	-1.371	-0.131	-4	-5
LS-603 Los Angeles Abrasion, %	24.100	22.800	22.178	22.122	1.667	0.770	3	5
LS-607 Percent Crushed Particles	69.900	69.100	69.139	69.314	0.200	-0.057	5	-5
LS-608 % Flat & Elongated Particles	5.900	3.900	6.960	6.720	-0.418	-1.183	-5	-4
LS-609 Petrographic Number (Concrete)	211.60	189.80	-	-	-	-	-	-
LS-614 Freeze-Thaw Loss, %	**6.900**	**7.500**	**3.303**	**3.160**	***3.281**	***3.852**	**0**	**0**
LS-618 Micro-Deval Abrasion Loss (CA)	11.500	11.000	11.472	11.514	0.063	-0.956	5	-5
LS-620 Accelerated Mortar Bar (14 Days)								

Blank spaces represent not tested.
Bold and Underline * - Calculation considered outlier
∩ - Outliers by Manual Deletion

Table 2. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: November 15, 2013					
FINE AGGREGATE REFERENCE SAMPLES 1.13 & 2.13								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.13	2.13	1	2	1	2	1	2
LS-623								
Maximum Wet Density (g/cm^3)	**2.538**	2.490	**2.422**	2.425	***4.911**	2.679	**0**	1
Maximum Dry Density (g/cm^3)	**2.385**	2.340	**2.265**	2.267	***4.797**	2.712	**0**	1
Optimum Moisture, %	6.410	6.400	7.046	7.021	-2.444	-2.351	-2	-2
LS-604 – Coarse Aggregate								
Relative Density (O.D.)	2.621	2.618	2.625	2.624	-0.577	-1.102	-5	-4
Absorption	1.160	1.140	1.133	1.126	0.356	0.197	5	5
LS-621								
Asphalt Coated Particles, %	54.500	60.000	54.433	54.833	0.023	1.747	5	3

Blank spaces represent not tested.
Bold and Underline * - Calculation considered outlier
∩ - Outliers by Manual Deletion

Table 3. Summary of Results for Laboratory 47

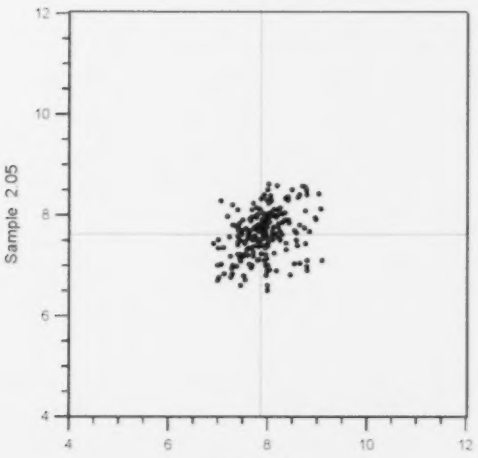
TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: November 15, 2013					
FINE AGGREGATE REFERENCE SAMPLES 3.13 & 4.13								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	3.13	4.13	3	4	3	4	3	4
LS-605 – Fine Aggregate								
Relative Density (O.D.)	2.649	2.651	2.650	2.650	-0.109	0.043	-5	5
Absorption	1.220	1.190	1.351	1.329	-0.835	-1.142	-5	-4
LS-606 – Coarse Aggregate								
$MgSO_4$ Soundness Loss, %	1.500	2.500	3.693	3.541	-1.236	-0.551	-4	-5
LS-606 – Fine Aggregate								
$MgSO_4$ Soundness Loss, %								
LS-619 – Fine Aggregate								
Micro-Deval Abrasion	14.800	14.200	15.609	15.741	-0.671	-1.273	-5	-4
LS-602 – Fine Aggregate								
Percent Passing 2.36 mm	45.400	42.500	44.871	44.490	0.273	-1.126	5	-4
Percent Passing 1.18 mm	39.100	35.200	37.622	37.324	0.758	-1.235	5	-4
Percent Passing 600 µm	27.900	25.100	27.408	27.368	0.323	-1.518	5	-3
Percent Passing 300 µm	14.500	13.800	14.069	14.100	0.511	-0.355	5	-5
Percent Passing 150 µm	10.400	10.300	10.321	10.336	0.122	-0.063	5	-5
Percent Passing 75 µm	8.650	8.700	8.689	8.714	-0.071	-0.027	-5	-5

Blank spaces represent not tested.
Bold and Underline * - Calculation considered outlier
∩ - Outliers by Manual Deletion

Table 4. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: November 15, 2013					
SOILS REFERENCE SAMPLES 5.13 & 6.13								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	5.13	6.13	1	2	1	2	1	2
LS-702 – Sieve Analysis of Soil								
Percent Passing 2.00 mm	99.900	100.00	99.594	99.852	0.959	0.769		
Percent Passing 425 µm	97.800	98.000	96.701	96.997	1.625	1.846	3	3
Percent Passing 75 µm	92.900	93.200	91.350	91.667	1.527	1.665	3	3
Percent Passing 20 µm	84.600	83.800	79.325	79.282	1.569	1.472	3	4
Percent Passing 5 µm	66.000	65.900	59.395	58.940	1.941	2.271	3	2
Percent Passing 2 µm	**52.600**	50.000	**43.901**	43.900	***3.591**	2.152	**0**	2
LS-703								
Liquid Limit, %	39.600	39.000	37.144	37.069	1.848	1.394	3	4
LS-704								
Plastic Limit, %	19.900	20.000	18.813	18.734	0.853	1.109	5	4
Plasticity Index, %	19.700	19.000	18.369	18.341	0.835	0.455	5	5
LS-705								
Specific Gravity of Soil	2.743	2.765	2.733	2.734	0.407	1.252	5	4
AGGREGATE CONSENSUS PROPERTIES								
Uncompacted Void Content	41.800	42.500	42.206	42.270	-0.637	0.351	-5	5
Sand Equivalent Value	58.800	56.400	42.767	42.674	1.995	1.785	3	3
Percent Fractured Particles	71.500	72.800	71.443	71.453	0.012	0.312	5	5
% Flat & Elongated Particles	0.900	0.700	1.434	1.433	-0.664	-0.940	-5	-5

Blank spaces represent not tested.
Bold and Underline * - Calculation considered outlier
∩ - Outliers by Manual Deletion

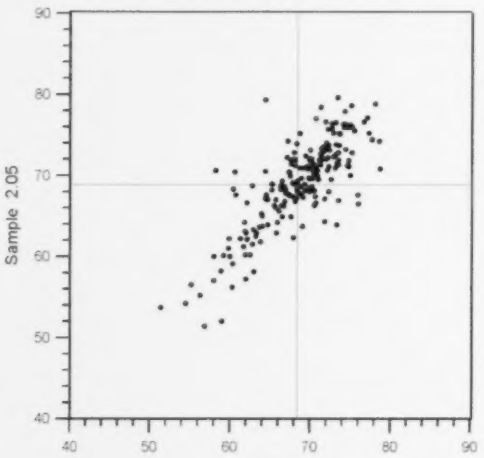


Test 25: Percent Passing the 75 um Sieve

	Mat 1	Mat 2
Mean	7.930	7.630
Median	7.800	7.500
Std Dev	0.460	0.470
n = 203		

Labs Eliminated: 447, 497, 452, 518

Scatter diagram for a test showing random variation with little laboratory bias

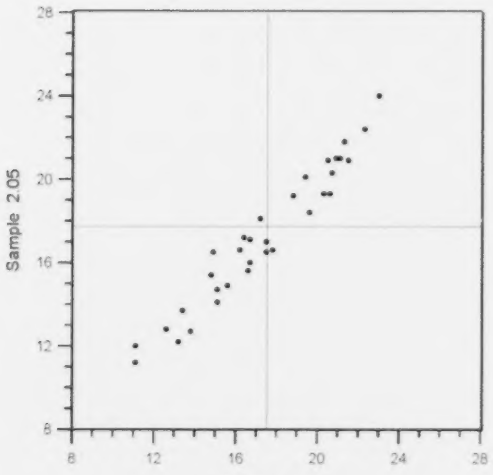


Test 12: Percent Crushed Particles

	Mat 1	Mat 2
Mean	68.491	68.905
Median	68.300	64.500
Std Dev	5.054	5.402
n = 201		

Labs Eliminated: 345, 350, 436, 480

Scatter diagram for a test showing a combination of random variation and laboratory bias for some laboratories

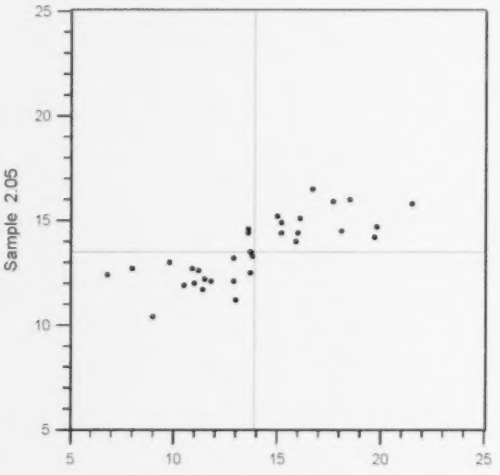


Test 29: MgSO4 Soundness (Fine Aggregate), % Loss

	Mat 1	Mat 2
Mean	17.370	17.258
Median	15.600	15.600
Std Dev	3.276	3.325
n = 32		

Lab Eliminated: None

Scatter diagram for a test showing pronounced between laboratory bias and equal variation for each material



Test 11: MgSO4 Soundness (Coarse Aggregate), % Loss

	Mat 1	Mat 2
Mean	13.890	13.570
Median	12.900	13.600
Std Dev	3.533	1.541
n = 31		

Lab Eliminated: None

Scatter diagram for a test with pronounced between laboratory bias but unequal variation for each material

Figure 1. Examples of Scatter Diagrams

2.3 OUTLIERS

In dealing with suspected outlying observations or 'outliers', our purpose is to remove those observations that do not belong to the sample population and to provide some statistical criteria for doing so. There are a number of ways to do this. In most of these, as ASTM E178 states, 'the doubtful observation is included in the calculation of the numerical criterion (or statistic), which is then compared with a critical value based on the theory of random sampling to determine whether the doubtful observation is to be retained or rejected.' The critical value is that value of the sample criterion that would be exceeded by chance with some specified (small) probability on the assumption that all observations did indeed constitute a random sample from a common system of causes, a single parent population, distribution, or universe.

The MTO study often follows the criteria recommended for single samples in Section 4 of ASTM E178 for rejecting the doubtful observations at the ninety-five percent confidence level. The critical value method is based on the assumption of normality, and the critical values are calculated using Student's T distribution. The assumption in this method is that all of the observations come from the same normal population. The doubtful observation is included in the calculation of mean and standard deviation of the population. Then the critical value, T_n, for that observation, n, in question is calculated and compared with the critical value based on the theory of random sampling. The doubtful observation is rejected if T_n is higher than the critical value for the five percent significance level. The outlier is removed from the data set and the iterations are continued until no outliers are detected, and a revised mean and standard deviation are calculated after deleting the outlier. The ratings of the laboratories are determined based on the revised mean, standard deviation, and standardized deviate.

In some cases, the strict application of the critical value method tends to include laboratories in the population that report extraneous results. These results may not represent testing performed in conformance with the test method. In those cases, the application of the iterative technique (Manchester[6]) is used. The Constant C in the iterative technique is computed using Fisher's F distribution, and it depends on the number of participating laboratories in a particular test. In this technique, an outlying observation is rejected based on a statistical criterion, but the confidence interval may vary depending on the number of participants and the distribution of sample population.

In the iterative technique, after screening the test results for any errors, the doubtful test result is included in the calculation of mean and standard deviation of the data set. The absolute residual values (actual test result minus the mean) are then computed and test result farthest from the mean by a unit of Cs (standard deviation, s, multiplied by a constant C) is identified as an outlier. One outlier at a time is identified and rejected in a manner similar to that of critical value method.

6 The Development of an Interlaboratory Testing Program for Construction Aggregates, by L. Manchester, Ministry of Transportation, Ontario, Engineering Materials Office Report EM-33, Downsview, December, 1979.

Three of the test methods included in this proficiency sample testing program requires reporting of control sample results to demonstrate that the testing process of the laboratory is in control. The laboratories that report control sample results outside the range of values established for the material are identified during the screening of test results for any errors or deviations. These laboratories are manually removed from the data set during the analysis and considered as outliers.

3. Discussion

The following discussion contains general and test-specific comments for the 2013 test period. Where ASTM, AASHTO or MTO precision statements are published for a given test, an attempt has been made to compare these with the statistics for this period.

A discussion of statistical techniques is presented in the Glossary of Terms, found in Appendix A.

3.1 NOTES ON MATERIAL SOURCES

Materials used in this test period were as follows:

- Coarse and fine aggregate tests, including Sieve Analysis, Percent Crushed Particles, Moisture Density Relationship, Relative Density and Absorption (fine), Micro-Deval Abrasion Loss (fine), Uncompacted Void Content, Sand Equivalent Value, and Percent Fractured Particles – Granular A (OPSS 1010) from Waterford Sand and Gravel, Simcoe Pit (MTO MAIDB No. S06-109).
- Coarse aggregate tests, including Wash Pass 75 μm, Percent Flat and Elongated Particles, Petrographic Analysis (coarse), Relative Density and Absorption (coarse), Los Angeles Abrasion, Micro-Deval Abrasion Loss (coarse), Freeze-Thaw Loss, Magnesium Sulphate Soundness (coarse), and Percent Flat, Elongated, or Flat and Elongated Particles – clear-stone (OPSS 1003) from a quarry south of Hamilton, north of Lake Erie.
- Fine Aggregate Petrographic Examination - sand from Inland Arkona Pit, London (MTO MAIDB No. P04-123)
- Soil tests – Glacial Lake Iroquois deepwater laminated silt and clay from Walker Brothers Vineland I Quarry, N03-023.

3.2 NOTES ON SAMPLE PREPARATION

The material processed for the coarse and fine aggregate tests conforms approximately to the gradation requirements of Granular A. Bulk samples were prepared using a large spinning riffler, developed and built by staff at the MTO Downsview Laboratory (refer to Figures 2 and 3 of Report MI-179, February 2000). The use of a spinning riffler ensures that, as far as possible, each sample is identical to every other sample. It has been found that this is the best technique for minimizing sample bias. A bobcat loader was used to fill an aggregate bin from the stockpile and the material was fed along a conveyor belt to fill 33 identical bags (fitted with funnels) on a spinning turntable. It was found that about 18 revolutions of the turntable were required to fill each bucket to 23 ± 2 kg of Granular A. This resulted in more homogeneity of the samples than would normally be the case using other techniques. In total, six hundred and fifty 23 ± 2 kg samples were prepared for the tests on Granular A, and randomized for distribution to participating laboratories. The participants were responsible for the preparation of their own fine aggregate samples (3.13 and 4.13) from the two bags of

Granular A supplied.

In addition to Granular A, additional samples consisting of material with approximately 98% retained on 4.75 mm sieve was also supplied for tests that require coarse aggregates. The number of revolutions of the turntable required for coarse aggregate to fill each bucket to approximately 28 ± 2 kg was found to be about 24 revolutions of the turntable. In total, six hundred and fifty 28 ± 2 kg samples were prepared for the coarse aggregate tests, and randomized for distribution to participating laboratories.

Soil material was air-dried, processed to pass through a 2.0 mm sieve using a Fritsch Soil Mill Pulveriser, and placed in 20 kg buckets. Individual scoops were collected from each bucket and placed in a separate container. The material from the container was then transferred to the hopper of a small spinning riffle splitter. The hopper of the spinning riffler used is capable of filling 24 identical 2 kg containers per run. This method was used to create uniform 20 kg buckets. The proficiency test material was then prepared by obtaining representative samples from a 20 kg bucket. The material collected from the 20 kg bucket was then transferred to the hopper of the small spinning riffler and the 500 g proficiency test samples were prepared. The samples were then randomized for distribution to participating laboratories.

3.3 NOTES ON INDIVIDUAL TESTS

For each test, comments have been made pertaining to the variation illustrated by the associated scatter diagrams shown in Appendices D1 and D2. The technique used to test for outliers is stated and, where possible, reasons for the outlying observations are offered. It is important to keep in mind that there are many variables influencing laboratory testing.

A summary of the statistical data is presented in the Multi-Laboratory Precision Tables found in Appendix C. Besides the comparison made to ASTM, AASHTO or MTO precision statements, comparison of the variation between previous test periods is made for each of the tests. Because the materials usually differ from year to year, it is emphasized that the comparison between years should be used only as a guide. It is important to note that the yearly use of different materials will have some effect on the variation exhibited in some tests, while it will have relatively little effect on others. For example, the magnesium sulphate soundness test normally exhibits increased variation as higher mean loss is reported. A coarse aggregate sample having an average mean loss of twenty percent would likely show more variation than a coarse aggregate sample having an average mean loss of ten percent. On the other hand, a sieve analysis could be performed on those same two aggregates, with the percent passing each sieve and the variation being remarkably similar for the two samples.

3.4 PROFICIENCY SAMPLE TESTS

3.4.1 LS-601 - Wash Pass 75 µm (Coarse Aggregate) – Test No. 1

Two hundred and twenty-two laboratories reported results for this test in 2013. Twenty-one outliers were identified and rejected using the iterative technique. The standard deviations of 0.28 and 0.25 obtained in 2013 are slightly lower than the values that were reported in the 2012 study and comparable to the values reported in 2010 and 2011 studies. However, the standard deviations obtained in 2013 are slightly higher than the multi-laboratory variation of 0.19 published in the MTO Test Method LS-601 for aggregates with less than 2.0% material passing the 75 µm sieve and comparable to that of the value (0.22) published by ASTM C 117 for aggregates with 1.5% of material finer than the 75 µm sieve. The mean value of the aggregate used in 2013 consisted of approximately 1.2% material finer than 75 µm, which is within the range of values for which the ASTM and MTO precision statements were established. Further, the coefficient of variation of 21.7% obtained in 2013 is significantly lower than the values of 34.2% and 26% reported in 2010 and 2011, respectively, but it is slightly higher than the value of 13.5% obtained in 2012. The scatter diagram provided in the Appendix D1 shows a combination of random variation and laboratory bias for some laboratories. The laboratories that are identified as outliers should examine their test procedure more closely, especially the achievement of constant dry mass at the beginning and end of the test.

3.4.2 LS-602 - Sieve Analysis (Coarse Aggregate) – Test Nos. 2 to 6

These tests represent the coarse aggregate portion of the Granular A sample gradation. Tests 20-25 carried out on the material passing 4.75 mm sieve as prepared by the participants (samples 3.13 and 4.13) represent the remainder of the gradation. The data is presented in percent passing format and is compared to precision statements developed in the same format by Vogler and Spellenberg[7].

The Granular A samples 1.13A and 2.13A supplied for the sieve analysis test consisted of approximately 45.5% of the material retained on 4.75 mm sieve, and conform to the grading of Granular A materials used in the past MTO Aggregate and Soil Proficiency Sample Testing Programs. The gradings reported for Test Nos. 2-6 represent the combined gradings of coarse and fine aggregates. The proficiency test samples were prepared with the large spinning riffler described in Section 3.2.

The standard deviations obtained in 2013 for all of the sieves, with the exception of 19.0 mm sieve, are found to be significantly lower than the expected variations given in the ASTM C 136 precision statements. In the case of 19.0 mm sieve, the standard deviation of 0.8 obtained is almost twice that of the precision estimate (0.35) published by ASTM.

Two hundred and twenty-three laboratories reported results for the sieve analysis test in 2013. Outliers were eliminated using the iterative technique. Successive scatter diagrams

7 Vogler, R.H., Department of Transportation, Michigan, AASHTO Technical Section 1c; T27 and Spellenberg, P.A., AASHTO Materials Reference Laboratory; Unpublished Paper.

show a fairly uniform distribution of points about the mean (i.e. a random variation with little laboratory bias). The number of outliers identified varies from sieve to sieve, and ranges from ten for the 19.0 mm sieve to a maximum of twenty-two for 9.5 mm sieve.

Possible reasons for outlying observations include factors that impact the measurement process such as sieve condition (state of repair and cleanliness), efficiency of the sieving process and apparatus, initial sample mass, and mass on a given sieve. If your laboratory has performed poorly in this test period, you should inspect your sieves (use CAN/CGSB-8.1-88 or ASTM E11 as guides) and your sieve shaker(s) thoroughly, and, once satisfied that they are in order, perform a sieving efficiency test as described in LS-602 to pinpoint any problems.

3.4.3 LS-603 - Los Angeles Abrasion Loss (Coarse Aggregate) – Test No. 8

Only ten laboratories reported results for this test in 2013. One outlier was detected by the use of critical value method. Considering the number of observations (10) used, the analysis may not yield any meaningful or representative statistical data. The lower left and upper right quadrants together account for eight of the ten points, which is evidence of significant laboratory biases. This test shows systematic variation, as was found in previous years. However, the standard deviations obtained in 2013 are slightly lower than the values that were reported in the past three years.

ASTM precision statements for 19.0 mm maximum size coarse aggregate, with percent loss in the range 10% to 45%, give a multi-laboratory coefficient of variation of 4.5%. Therefore, the results from two different laboratories should not differ by more than 12.7%. The mean loss of 22.1% in this test is within the range of values for which ASTM C 131 data was established. This year's coefficient of variation (average 4.7%) is consistent with that of the value, 4.5%, given in the ASTM precision statements.

3.4.4 LS-604 - Relative Density of Coarse Aggregate – Test No. 9 and Absorption of Coarse Aggregate – Test No. 10

MTO Test Method LS-604 follows the procedures described in ASTM C 127-12 for the determination of relative density (Test No. 9) and absorption property (Test No. 10) of coarse aggregates. ASTM C 127 provides precision statements only for relative density. It does not provide precision estimates for the absorption property. In the case of LS-604, it provides precision estimates for both relative density and absorption of coarse aggregates with absorption properties less than 2.0%. The precision statements published in LS-604 were established using the data collected for a period of twelve years, through the MTO Proficiency Sample Testing Program.

One hundred and four laboratories reported results for these tests in 2013. Six laboratories for relative density and three laboratories for absorption were identified as outliers using the iterative technique. The standard deviation of 0.006 obtained for bulk relative density in 2013 is slightly lower than the values that were reported in the past three years and are consistent with the precision estimate of 0.006 published in the LS-604. Further, the

standard deviations obtained in 2013 are one-half of the value of 0.013 published in ASTM C 127. In the case of absorption test, the standard deviations of 0.076 and 0.072 obtained this year are slightly lower than the precision estimate of 0.09 provided in the LS-604. In addition, the coefficient of variation of 6.5% obtained in 2013 is consistent with the value of 6.1% obtained in 2012 and it is considerably lower than the values 8.4% and 12.3% reported in 2010 and 2011, respectively. The scatter diagrams for both Test Nos. 9 and 10 show a combination of random variation and laboratory bias for some laboratories.

3.4.5 LS-606 - Magnesium Sulphate Soundness (CA) – Test No. 11

Forty-four laboratories reported results for this test in 2013. No outlier was identified by the use of critical value method or iterative technique. The scatter diagram shows a pronounced between laboratory bias. All of the points, with the exception of four (9%), are accounted in the lower left and upper right quadrants. This test has historically shown high coefficients of variation due to the difficulty of maintaining solution of the correct density and insufficient drying by some laboratories. The average mean loss of 3.6% in this test is significantly lower than the range of values (9% to 20%) for which the ASTM C 88 precision estimate was established. The coefficient of variation of 51.4% obtained in 2013 is more than twice that of the values reported in the 2011(17%) and 2012 (20.8%) studies and also, the value published in the ASTM precision statements. ASTM reports a multi-laboratory coefficient of variation of 25% for coarse aggregate with percent loss in the range of 9% to 20%.

3.4.6 LS-607 - Percent Crushed Particles – Test No. 12 and Percent Cemented Particles – Test No. 7

The coarse aggregate samples supplied did not contain adequate amount of material retained on the 19.0 mm sieve. For this reason, participants were advised to perform the test only on coarse aggregate passing the 19.0 mm sieve and to calculate the weighted average by assigning the same percent crushed particles value as the next smaller fraction (i.e., 19.0 mm - 13.2 mm) for 26.5 mm to 19.0 mm that need not be tested.

This year, two hundred and twenty-two laboratories submitted results for this test. Fourteen laboratories were selected as outliers by employing the iterative technique. The standard deviations of 3.7 and 3.8 obtained in 2013 are significantly lower than the precision estimate of 4.7 published in the MTO LS-607 and the values ranging from 5.1 to 7.1 reported in the past three years. The standard deviations in 2013 are also significantly lower than the value of 6.0 obtained during the 1989 MTO workshop. The average mean of 69.2% in this test is within the range of values (55% to 85%) for which the MTO precision statements were established. The scatter diagram shows a combination of random variation and operator bias for some laboratories. ASTM has a very similar test method (D 5821) but has not conducted interlaboratory studies to determine precision and currently publishes precision data (standard deviation of 5.2 for a mean percent crushed particles value of 76.0%) obtained from MTO study. The marked improvement in the multi-laboratory variations obtained this year may have resulted from the clarity that was provided in the latest revision of MTO LS-607, for the calculation of weighted average of percent crushed particles

3.4.7 LS-608 - Percent Flat and Elongated Particles – Test No. 13

The determination of a flat and/or elongated particle is dependent on operator skill and judgement in using the measurement tool. The ASTM and CSA procedures use a proportional calliper device to measure the *greatest* length or width to thickness ratio. The MTO procedure previously measured the ratio of *mean* length or width to the *mean* thickness (MTO Laboratory Manual Revision 15 and earlier). The MTO procedure (Revision 16 and up) has been modified to agree with the ASTM definition. All participants should be using the latest MTO version of the test method. Flat and elongated particles are defined in the MTO Test Method LS-608 as those pieces whose greatest dimension in the longitudinal axis, compared to the least dimension in a plane perpendicular to the longitudinal axis, exceeds a ratio of 4:1. This test method is similar to that of ASTM D 4791 and uses the same definition, with the exception of ratio, for the flat and elongated particles. In ASTM, the flat and elongated particles are defined as the pieces that exceed a ratio of 3:1 or 5:1. In LS-608, the test sample is separated into number of fractions and the weighted average of percent flat and elongated particles is calculated using the result of every fraction tested.

The coarse aggregate samples supplied did not contain adequate amount of material retained on the 19.0 mm sieve. For this reason, participants were advised to perform the test only on coarse aggregate passing the 19.0 mm sieve and to calculate the weighted average by assigning the same percent flat and elongated particles value as the next smaller fraction (i.e., 19.0 mm - 13.2 mm) for 26.5 mm to 19.0 mm that need not be tested.

Two hundred and twenty-one laboratories reported results for this test in 2013. Iterative technique was used to reject six outliers. LS-608 provides precision estimate for coarse aggregate passing 19.0 mm and retained on 4.75 mm with percent flat and elongated particles ranging from 2.0% to 9.5%. The standard deviations of 2.4 and 2.5 obtained in 2013 are slightly higher than that of the values (1.8 and 1.9) reported in 2012. However, the multi-laboratory variations are consistent with the precision estimate of 2.3 published in LS-608. The average mean of 6.8% in this test is within the range of values (2% to 9.5%) for which the MTO precision statements were established.

ASTM D 4791 is similar to LS-608 for comparison of multi-laboratory precisions obtained. In ASTM, the precision estimates are provided for individual fractions ranging from 19.0 mm to 4.75 mm (19 mm to 12.5 mm, 12.5 mm to 9.5 mm, and 9.5 mm to 4.75 mm), and the estimates are based on the coefficient of variation. A direct comparison of the precision estimates from ASTM is not appropriate with that of the estimates provided in LS-608. The precision estimates published in LS-608 are on the basis of standard deviation, and was estimated from the weighted averages calculated using the results of four fractions ranging from 19.0 mm to 4.75.mm.

The scatter diagram provided in the Appendix D1 shows a combination of random variation and laboratory operator bias for some laboratories. In general, laboratories that reported values in excess of 12% or less than 2% should critically examine their equipment and procedure.

3.4.8 LS-609 - Petrographic Analysis (Coarse Aggregate) – Test No. 14

The coarse aggregate examined in 2013 was from a quarry located in the Niagara Peninsula extracting out of the Middle Devonian Dundee Formation. In general the bedrock in the area of extraction consist of horizontally bedded, light grey brown to light grey, cherty crystalline and fossiliferous limestone. Chert occurs as both nodules and bands parallel to the bedding throughout most of the geological section. Other rock types present include shaley limestone and bituminous limestone. At least one bed of large porous colonial and solitary corals is present near the base of the quarry. This bed locally contained petroleum staining and/or a strong petroleum odour that may have been noticed in some particles handled by participants.

This sample may have been challenging for many analysts in the correct identification of chert. The chert was generally white to light grey or light grey green in colour, but also included minor dark grey varieties. Lighter coloured chert was commonly carbonaceous, slightly chalky, and locally appeared mottled with darker grey brown inclusions. Lustre ranged from dull and porcelainous (leached and semi-leached) to waxy or vitreous (unleached). Distinguishing between leached and semi-leached chert is based on the rate of water absorption. Absorptive chert (leached) will generally stick to the tongue. Participants are also reminded that the Moh's hardness of chert is seven, equivalent to that of crystalline quartz, therefore it should not scratch easily with a knife and will typically leave a grey streak of metal transferred from the blade to the particle.

Worksheets were submitted by 35 analysts from approximately 26 laboratories. There were no analysts that completed results for more than one laboratory. Calculation and typographical errors were noted on several submissions. In several instances PN worksheets were not completed in full and in a few cases the results were illegible and difficult to discern. Participants are reminded that it is required to complete the worksheets in full, to report the PN as a whole number, and to ensure that the data entered on the worksheets are legible. Please see Appendix E1 for a summary of the Petrographic Number Test submissions received for 2013.

This year, the test results included a high number of anomalies, including procedural errors and misidentification of specific rock types. As a result, a comprehensive statistical analysis of the data was not completed for the 2013 program samples.

The following is a list of noted issues with the as-received test data:

- Laboratories 30, 38, 61, 80, 260 and 316 did not examine the required 1500g as per the 2013 MTO Aggregate and Soil Proficiency Sample Program Instructions;

- Laboratories 1, 13, 30, 61, 102, and 293 identified significant amounts (>2%) of sandy carbonates (Rock Types 2 and/or 40) that were not present in the sample. Analysts are reminded that to classify particles as sandy carbonate the rock must contain between 5 and 49% sand-sized quartz grains. In addition, MTO files on this quarry over their 50 year span have not reported the presence of this rock type;

- Laboratory 183 reported the presence of marble (Rock Type 23) which was not present in the sample;

- Laboratory 61 reported the presence of Rock Type 3 which was not present in the sample;

- Laboratory 102 reported the presence of flint/jasper (Rock Type 81), which was not present in the sample. Rock Type 81, is typically reserved for the classification of rock types associated with banded iron formation deposits. This material may have been better placed in Rock Type 26, where the particle likely consisted of dark grey coloured unleached chert;

- Laboratory 30 reported Carbonate (carbonaceous coral, coral) as a separate rock type in both the good and fair categories. Although not necessarily incorrect, this material might have been better placed in the pitted carbonate category (Rock Type 41) unless the analyst strongly felt that the hardness and quality of the particle warranted placing in another quality category;

- Some laboratories did not report any amount of Rock Type 26 and/or Rock Type 45. This is a significant omission as large portions of the strata in this quarry are known to contain between 5 and 20% chert (MTO internal files). There was also no consistency in the amounts of Rock Types 26 and 45 reported across all laboratories. Range of Rock Type 26 reported as received was 0 to 20%, and range of Rock Type 45 reported as received was 0 to 19%. This indicates an inherent difficulty with the identification of chert as well as an inconsistency between operators in distinguishing between the leached and unleached varieties of chert.

- Reported amounts of Rock Type 35 ranged from 0 to 26%. Cause of this variation possibly may have been confusion between shale and bituminous rich seams in the limestone, the latter of which is common in this source.

Reported PN values from all laboratories ranged from 104 to 212.

The reported data, as received from all laboratories indicated the following category ranges: good aggregates, 65 to 98%; fair aggregates, 2 to 35%; and poor aggregates, 0 to 20%. Deleterious aggregates were only reported by 5 labs to a maximum amount of 0.5%.

For reference, ten additional samples were analyzed by a single MTO analyst and checked by the Petrographer. For these samples, the ranges of material in the following rock type categories were reported: good, from 81 to 87%; fair, from 4 to 13%; and poor, from 4 to 10%. No deleterious category aggregates were reported. This yielded PN values ranging from 140 to 167 for this material.

The wide variation in the data from this year as well as in the previous year (MTO report MERO-046) demonstrates a strong need for additional training and education of analysts that perform the petrographic number test. Consistency in rock identification as well as incorrect

rock identification is the main issues. This is particularly emphasized with respect to the carbonate rock types and chert, including shaley carbonates, slightly shaley carbonates, cherty carbonates and leached/unleached chert. Another area recommended for clarification is discerning between shale and bituminous rich seams in carbonate rock types.

The similar ASTM standard for this test, C-295, does not report a petrographic number and has no precision statement.

3.4.9 LS-616 - Petrographic Examination (Fine Aggregate) – Test No. 15

The fine aggregate examined in 2013 was sand from the Inland Arkona Pit, located 2.5 km south east of Arkona, Ontario (MAIDB Number P04-123). Eleven analysts from seven laboratories examined samples 1.13 and 2.13 and submitted worksheets showing subdivision according to rock/mineral type. This year there were no analysts that completed results for more than one laboratory. The results are shown in the Appendix E2 and were evaluated by C.A. MacDonald, MTO Petrographer.

The reported results indicate an average composition of approximately 40% silicate (including sandstone, quartz, and other Precambrian Shield minerals and lithologies such as gabbro, metabasalt, feldspar, and granite), 55% carbonate, 2% shale and 3% chert. Minor amounts of mica (0.1% average) were also present, mostly concentrated on the P600/R300 and finer sieve sizes. The average amounts of silicate, shale and chert present combined (approximately ~45%) correlates well with insoluble residue of 45.6% for this sample. Silicate and mica contents tended to increase from larger to smaller sieve sizes, while chert and shale contents decreased.

The results of petrographic testing for each sieve fraction were also examined individually. To aid in this, MTO completed insoluble residue testing (IR) on samples of each individual fraction of the sand as well as on one overall representative sample of the sand in an attempt to correlate and cross check with the results of the petrographic examination. Insoluble residue test determines the resistance of aggregates to loss when exposed to a hydrochloric acid solution. Carbonate minerals are dissolved by a hydrochloric acid solution, and after complete digestion a remaining residue is left that consists of the non-carbonate components of the material. Results of the IR testing by MTO on this sand are summarized below (Table 1).

Table 5. Insoluble Residue Test Results (LS-613)

Fraction	Mass Tested (g)	IR (%)	Carbonate (%)
P4.75 (full)*	196.3	45.6	54.4
P4.75/R2.36	130.2	42.2	57.8
P2.36/R1.18	129.8	38.8	61.2
P1.18/R600	130.0	41.6	58.4
P600/R300	130.1	49.0	51.0
P300/R150	130.1	59.3	40.7
P150/R75	144.6	56.6	43.4

*Representative sample

The reported petrographic results had average carbonate content on the P4.75/R2.36 fraction of approximately 68%, with a range in reported values of 60 to 76%. Insoluble residue data for this fraction indicates the total carbonate content was approximately 58%. One possible reason for the difference between the petrographic data and insoluble residue results may have been that sandstone and siltstone particles with calcareous cement may have been misclassified as carbonate particles when tested with HCl. Participants that reported values above 70% carbonate for this fraction may wish to re-examine their samples.

Average petrographic carbonate content reported on the P2.36/R1.18 fraction was 64%, with a range in reported values of 42.5 to 82.5%. Insoluble residue data for this fraction indicates the total carbonate content was approximately 61%. Reasons for the difference in petrographic average versus insoluble residue results may be as described above. Participants that reported either very high or very low amounts of carbonate on this sieve fraction should re-examine their samples.

Average petrographic carbonate content reported on the P1.18/R600 fraction was approximately 60%, with a range in reported values of 36 to 77%. Insoluble residue data for this fraction indicates the carbonate content was approximately 58%. Participants that reported either very high or very low amounts of carbonate on this sieve fraction should re-examine their samples.

Average petrographic carbonate content reported on the P600/R300 fraction was approximately 49%, with a range in reported values of 33 to 62%. Insoluble residue data for this fraction indicates the carbonate content was approximately 51%.

Average petrographic carbonate content reported on the P300/R150 fraction was approximately 40%, with a range in reported values of 16 to 64%. Insoluble residue data for this fraction correlates very well with the petrographic average, indicating the carbonate content was approximately 41%.

Average petrographic carbonate content reported on the P150/R75 fraction was approximately 36%, with a range in reported values of 14 to 68%. Insoluble residue data for this fraction indicates the carbonate content was approximately 43%. Possible reasons for the difference between the petrographic data and insoluble residue results could be the difficulty in correctly identifying the difference between quartz and carbonate at such a small particle size. Those laboratories that reported carbonate values that significantly deviated from the averages and/or the amounts indicated by the insoluble residue testing should re-examine their samples.

Except for the P4.75/R2.36 and P150/R75 fractions, the petrographic average amounts of carbonate reported for each fraction correlated extremely well with the insoluble residue testing (generally within 1 to 3%). Participants that reported amounts of carbonate that deviated significantly from these amounts should re-examine their samples.

Shale and chert were correctly recognized by all laboratories, although there were large ranges in reported values on individual sieve fractions between laboratories (Appendix E2). The shale was typically dark brown to dark grey brown in colour, soft, and absorptive, and

generally did not effervesce when hydrochloric acid was applied. Chert was generally of the leached variety and appeared white in colour with a porcelainous to earthy lustre.

The wide range in petrographic values reported for carbonate and other components of this sample in their various fractions is concerning and suggests that additional training and/or education of analysts may be necessary. One possible reason for the wide variation could be misclassification of sandstone or siltstone particles with calcareous cement in the carbonate category. Another possible source of confusion could be related to the friable nature of some silicate components at smaller particle sizes (i.e. 600 µm and finer). Some of these particles tend to easily break or fracture when applying moderate pressure with a needle or metal probe, possibly leading an analyst to conclude that the particle is of low hardness and incorrectly belongs in the carbonate (or other) category.

Several laboratories did not report the minus 75 µm fraction of the gradation. Participants are reminded that for the purpose of calculating the weighted percent of components, the minus 75 µm fraction needs to be included, (assumed to have the same composition as the retained 75 µm sieve fraction).

The similar ASTM standard for this test, C-295, has no precision statement.

3.4.10 LS-618 - Micro-Deval Abrasion (Coarse Aggregate) – Test No. 16

Eighty laboratories reported results for this test in 2013. The test method requires reporting of control sample results to demonstrate that the testing process is in control. This year, one laboratory reported control sample results outside the established range and the lab was excluded from the analysis and identified as an outlier. In addition, three outliers were rejected using the iterative technique.

The multi-laboratory coefficient of variation of 5.5% published in the LS-618 is for 19.0 mm maximum size aggregate with abrasion losses in the range from 5% to 23%. The mean loss of 11.5% in this year's program is within the range of values for which the precision estimates were established. The average coefficient of variation of 4.3% obtained in 2013 is noticeably lower than the value published in LS-618, and that of the values reported in the past three years (4.4% to 5.4%). The scatter plot for this test shows random variation with little laboratory bias.

3.4.11 LS-614 - Freeze-Thaw Loss – Test No. 17

The coarse aggregate samples supplied did not contain adequate amount of material retained on the 19.0 mm sieve. For this reason, participants were advised to perform the test only on coarse aggregate passing the 19.0 mm sieve and to calculate the weighted average by assigning the same freeze-thaw loss value as the next smaller fraction (i.e., 19.0 mm - 13.2 mm) for 26.5 mm to 19.0 mm that need not be tested.

Sixty-two laboratories reported results for this test in 2013. The test method requires reporting of laboratory control sample losses to demonstrate that the testing process is in

control. This information is used to alert the laboratory to testing deficiencies. Without testing of the reference material, the test is invalid (see LS-614, Section 9.1). This year, all of the laboratories reported control sample result within the established range for the material. Two outliers were identified using the iterative technique.

The multi-laboratory coefficient of variation of 20.2% published in LS-614 is for coarse aggregate with freeze-thaw losses in the range of 4% to 18%. The coefficient of variation of 34.5% obtained in 2013 is significantly higher than the value of 20.2% published in the LS-614 and the values (20.6% to 29.3%) reported in the past three years. The majority of the points on the scatter plot (77.4%) are accounted in the lower left and upper right quadrant, indicating a pronounced laboratory bias.

It is likely that there are two main reasons for the wide spread of the data for this test: insufficient damage caused by freezing too rapidly or difference in sieving intensity. The laboratories that reported freeze-thaw losses higher than 5.5% should modify their processes to try and achieve losses closer to the mean loss of the control aggregate. Appendix 1 of LS-614 gives a procedure for determining and adjusting sieving time for quantitative analysis. Each laboratory must establish their sieving time, if the mechanical shaker and diameter of sieves are different from that were used to establish the sieving time provided in the Appendix 1 of LS-614.

3.4.12 LS-602 - Sieve Analysis (Fine Aggregate) – Test Nos. 20-25

The test samples for this procedure were prepared by the participants from the material passing the 4.75 mm sieve of the coarse aggregate gradation. This process closely follows the normal testing procedure in which the laboratory prepares its own test samples from the field sample. The scatter diagrams for the fine aggregate sieve analysis show random variation with little laboratory bias. The standard deviations of the fine sieves in 2013 are noticeably lower than that of the values reported in the 2012 study (MERO-046). The multi-laboratory variations, with the exception of 2.36 mm and 1.18 mm sieves, are found to be consistent with the values published in the ASTM C 136 precision statements. In the case of 2.36 mm and 1.18 mm sieves, the standard deviations obtained (1.7 to 1.9) are slightly higher than the value of 1.41 published by ASTM.

As in previous interlaboratory studies, it was found that the precision of the test varies as a function of the amount of material retained on any sieve. The smaller the amount of material retained, the more efficient the sieving process and the better the precision. When there is a small amount of material retained on a sieve (one layer of particles or less), the particles have a greater chance of falling through the sieve in a given time.

The number of outliers identified varies from sieve to sieve, and ranges from nine for the 75 µm sieve to a maximum of twenty for the 300 µm and 600 µm sieves. Outlier laboratories with a very low percent passing the 75 µm sieve should inspect their sieves, as low percent passing may be the result of the sieve being blinded when washing the sample. An ineffective washing process will also result in a low percent passing this sieve.

3.4.13 LS-605 - Relative Density of Fine Aggregate – Test No. 27 and Absorption of Fine Aggregate – Test No. 28

Participants in the program were asked to test the samples according to MTO Test Method LS-605. This test method follows ASTM C 128, except that it requires the removal of materials finer than 75 µm from the test specimen by washing. LS-605 requires the test specimens to be prepared in duplicate and washed on the 75 µm sieve until all of the material finer than 75 µm is removed. The presence of material finer than 75 µm in the test specimens can result in lower relative densities and higher absorption values.
In the past, MTO was using the precision estimates published in the ASTM C 128 for both relative density and absorption to compare and evaluate the multi-laboratory variations obtained from the MTO proficiency sample testing program. Considering the difference in preparation of test specimen between the ASTM C 128 and LS-604, use of the multi-laboratory variations published in the ASTM may not be appropriate to evaluate the performance of the participating laboratories. As a result, precision estimates were developed for LS-604 using the MTO proficiency sample test data collected over a period of twelve years. The latest revision of this test method provides precision estimates for both relative density and absorption of fine aggregates with absorption properties less than 2.0%.

One hundred and three laboratories reported results for these tests. Four outliers for relative density (Test No. 27) and ten outliers for absorption (Test No. 28) were selected using the iterative technique. As in previous years, greater variation exists in this test compared to the relative density test on coarse aggregate. It is imperative that differential drying of the various sized particles be avoided by *constant* stirring of the sample under the air current during the drying process. As short as 30-second periods of rest can be detrimental to the outcome of the test results. Differential drying of the particles is known to cause premature collapse in the cone test used to judge the saturated surface dry state. The resulting test observations are lower relative densities and higher absorption values.

The standard deviations obtained in 2013 for both relative density (0.013) and absorption (0.12 and 0.16) are consistent with the values published in the LS-605 and that of the values reported in the past three years (refer Appendix C). As in the previous studies, the multi-laboratory variations obtained in 2013 are significantly lower than that of the values published in the ASTM C 128 precision statements. ASTM publishes a multi-laboratory variation of 0.023 and 0.23 for relative density and absorption, respectively for fine aggregates with absorption properties less than 1.0%. The scatter plots for both tests, especially Test No. 28, show a pronounced between laboratory bias.

3.4.14 LS-621 - Amount of Asphalt Coated Particles – Test No. 30

Two hundred and twenty-two laboratories reported results for this test in 2013. Twenty laboratories were identified as outliers using the iterative technique. Scatter diagram provided in the Appendix D1shows a random variation and bias for some laboratories. LS-621 provides precision estimate for 19.0 mm maximum size coarse aggregate mixed with asphalt coated particles in the range of 25% to 45%. The average mean value of 54.6% reported by the laboratories is outside the range of values for which the precision estimate

was developed. The standard deviations of 2.9 and 3.0 obtained in 2013 are significantly lower than the precision estimate of 3.8 published in the LS-621 and the values that were reported in the past three years. Further, the coefficient of variation obtained in 2013 (5.3%) is significantly lower than the range of values (9.3% to 22.7%) obtained in the past three years of study. Laboratories that reported values of less than 48% and in excess of 60% should critically evaluate their interpretation of the definition and re-examine their samples. There is no comparable or similar ASTM test procedure.

3.4.15 LS-623 - Moisture-Density Relationship (One-Point) – Test Nos. 31-33

Participants were asked to perform this test on the material passing the 19.0 mm sieve of the Granular A samples 1.13A and 2.13A supplied. One hundred and fifty-five laboratories reported results for this test in 2013. Fourteen outliers for the wet density (Test No. 31) and nine outliers for optimum moisture (Test No. 33) determinations were rejected using the iterative technique. The standard deviations obtained in 2013 for all three tests, i.e. wet density, dry density and optimum moisture content are significantly lower than that of the values reported in the past three years and the precision estimates published in LS-623.

The majority of the points in the scatter diagrams are accounted in the lower left and upper right quadrant of the plots, indicating strong laboratory bias. Possible causes for the strong laboratory bias may be operator error and the use of an improper mould, even though the participants were requested to use only the 152.4 mm diameter mould. This test also requires significant operator skill to obtain the point within the band in the first attempt. Those laboratories with poor ratings should examine their equipment and procedure to discover the causes for this variation. There is no comparable or similar ASTM test procedure. However, ASTM D 698 covers the laboratory compaction characteristics of soils and reports precision estimates from the tests conducted on clayey soils.

3.4.16 LS-619 - Micro-Deval Abrasion (Fine Aggregate) – Test No. 34

Participants in this test were asked to prepare their own sample from the bags of bulk Granular A supplied. Eighty laboratories reported results for this test in 2013. The test method requires reporting of control sample test results to demonstrate that the testing process is in control. This year, none of the participants reported control sample results outside the range established for the material.

LS-619 provides precision estimates for fine aggregates with the abrasion loss in the range of 7% to 18%. The coefficient of variation of 7.7% obtained in 2013 is consistent with the precision estimate of 7.7% published in LS-619 and the values (6.2% to 7.9%) reported in the past three years.

One outlier was selected by the use of critical value method. The majority of the data points are located in the lower left and upper right quadrant of the scatter diagram indicating a strong laboratory bias.

3.4.18 LS-702 - Particle Size Analysis of Soil – Test Nos. 40-45

Participants in this test were instructed to submit the data sheets to demonstrate that the test was done according to LS-702. Based on the data sheets submitted, all of the laboratories performed the test in accordance with this test procedure. Ninety laboratories participated in the hydrometer test in 2013. Eighty-five percent of the laboratories reported results ranging from 98.5% to 99.9% of material passing the 2.00 mm sieve. For this reason, the data for 2.0 mm sieve (Test No. 40) was also subjected to the statistical analysis using no outlier technique. This technique does not assign rating for individual test. As a result, no rating was assigned for 2.0 mm sieve and the results of the analysis are reported for information purpose only.

Outliers were selected using the iterative technique. The number of outliers identified range from two for percent passing 75 um to a maximum of nine for percent passing 2 µm. Successive scatter diagrams for this test show pronounced between laboratory biases. The standard deviations obtained in 2013 for all the particle sizes passing, except 75 µm, and 425 µm, are consistent with that of the results reported in the past three years. The standard deviations obtained for the 75 µm and 425 µm sizes are slightly higher than the variations reported in the past three years. The laboratories that are identified as outliers should examine their equipment and technician's skills to ensure that they meet the requirements of the test procedure.

3.4.19 LS-703 and 704 - Atterberg Limits of Soil – Test Nos. 46-48

One hundred and eight laboratories reported results for Atterberg limit tests in 2013. Five outliers for liquid limit (Test No. 46) and four for plastic limit test (Test No. 47) were identified using the iterative technique. The scatter plots for both liquid and plastic limit tests as well as for plasticity index (Test No. 48) show strong laboratory bias. Both liquid and plastic limit tests require significant operator skills. Liquid limit test also requires good condition and calibration of the apparatus. Close attention to the condition and calibration of the liquid limit apparatus and employing skilled technicians may reduce the laboratory biases.

The variations obtained for liquid and plastic limit tests in 2013 are consistent with those of the values reported in the past three years. Further, the standard deviations obtained for plastic limit and plasticity index are consistent with the values published in the ASTM precision statements (refer Appendix C). However, the standard deviations obtained for liquid limit test are slightly higher than that of the precision estimate published in ASTM D 4318.

3.4.20 LS-705 - Specific Gravity of Soils – Test No. 49

The participants were requested to perform this test according to LS-705. This test method requires that the test be performed on a minimum of three specimens, and the difference between the largest and smallest (i.e., range) specific gravity values of the test specimens determined is within 0.02. Further, it requires that the test be repeated if the range exceeds

the specified limit. The laboratories that reported results with the range in excess of 0.02 appear to have difficulty in repeating the test within their testing environment. In 2013, four laboratories reported specific gravity values with the range in excess of the specified limit of 0.02. These laboratories were manually removed from the statistical analysis and identified as outliers.

Eighty-three laboratories reported results for this test in 2013. In addition to those laboratories that were removed manually, five more outliers were identified using the iterative technique. Ninety-five per cent of the data points are located in the first and third quadrants of the scatter diagram showing a pronounced between laboratory bias. Several steps in this test procedure can influence the results, particularly the equipment and method employed for preparation of the test specimen and removal of entrapped air from the test specimen. Laboratories finding themselves in this situation should carefully examine their equipment and procedure.

The standard deviation of 0.024 obtained in 2013 is consistent with the results reported in the 2012. LS-705 is similar to that of AASHTO T 100, which reports a multi-laboratory standard deviation of 0.04. As in the past three studies, the standard deviations obtained in 2013 are also found to be significantly lower than that of the precision estimate published in the AASHTO T 100.

3.5 SUPERPAVE CONSENSUS PROPERTY TESTS

3.5.1 LS-629 - Uncompacted Void Content (FA) – Test No. 95

The participants were asked to perform the test in accordance with LS-629, using the fine aggregate prepared by splitting the material passing 4.75 mm sieve of the Granular A. This test method is a modified version of AASHTO T 304. LS-629 follows Method A of AASHTO T 304, except for the preparation of the test specimen to be used in the determination of bulk specific gravity of fine aggregates. The significant difference between the methods is that LS-629 requires the test specimens be washed on the 75 µm sieve until all the material finer than 75 µm is removed. In addition, LS-629 specifies that the bulk relative density is determined using the graded sample and not the individual size fraction method described in Clause 9.4 of AASHTO T 304. In order to minimise the testing work, the participants were advised to use the bulk relative densities reported for fine aggregate determined in accordance with LS-605 under Test No. 27, to compute the uncompacted void contents of samples 3.13 and 4.13.

Seventy-two laboratories submitted results for this test in 2013. One laboratory was identified as outlier using the iterative technique. Eighty-six percent of the points on the scatter plot are accounted in the first and third quadrant, indicating a strong laboratory bias. The standard deviations of 0.64 and 0.65 obtained in 2013 are fairly consistent with the values obtained in the past three years. The standard deviations obtained for both samples are significantly higher than the value of 0.33% published in the ASTM precision statements for graded standard sand. The estimates of precision published in ASTM C 1252 are based on graded sand as described in ASTM C 778, which is considered rounded, and is graded

from 600 µm to 150 µm. The type of material used for the development of precision statements published in ASTM C 1252 may not be typical of the sand samples that were used in this testing program. The uncompacted void contents reported were calculated using the bulk relative densities that were determined by the individual laboratories. The use of the bulk relative densities determined by the individual laboratories further compounds the variations associated with the results reported for uncompacted void contents. ASTM C 1252 suggests that a difference in relative density of 0.05 will change the calculated void content by about one percent. The laboratories that are identified as outliers should review their test procedures and the skill of the technician.

3.5.2 ASTM D 2419 - Sand Equivalent Value of Fine Aggregate - Test No. 96

Participants were asked to prepare the fine aggregate sample for this test by splitting the Granular A material passing 4.75 mm sieve. Two alternate procedures for the preparation of test specimen (air-dry or pre-wet) are allowed in both ASTM and AASHTO methods. The participants were given the option of preparing the test specimen in accordance with either method.

Sixty-eight laboratories reported results for this test in 2013. No outlier was identified by the use of critical value method or iterative technique. The lower left and upper right quadrants of the scatter diagram account for 94% of the points showing pronounced laboratory bias. The standard deviations of 8.0 and 7.7 obtained in 2013 are significantly higher than the values reported in the past three years. However, these values are consistent with the multi-laboratory precision estimate of 8.0 published by ASTM for samples with sand equivalent value less than 80.

3.5.3 ASTM D 5821 - Percent of Fractured Particles – Test No. 97

The Granular A samples 1.13A and 2.13A supplied did not contain adequate amount of material retained on 19.0 mm sieve. For this reason, the participants were advised to perform the test only on coarse aggregate passing the 19.0 mm sieve.

ASTM D 5821 is very similar to MTO LS-607. Seventy-four laboratories submitted results for this test in 2013. Two outliers were detected using the iterative technique. The scatter diagram shows a pronounced between-laboratory bias. The average means determined by the ASTM method (71.5%) and MTO version (69.2%) on the same aggregate samples differs only by 2.3%, which is significantly lower than the multi-laboratory variations published by ASTM (5.2) and MTO LS-608 (4.7). Further, the standard deviations (4.3 and 4.6) obtained in 2013 are significantly lower than the precision estimate of 5.2 published by ASTM. ASTM has not conducted interlaboratory studies to determine a precision estimate and currently publishes statistical data provided by MTO. The variation obtained in 2013 is also noticeably lower than that of the values (4.9 to 6.4) reported in 2011 and 2012.

3.5.4 ASTM D 4791 - Percent Flat and Elongated Particles – Test No. 99

The coarse aggregate samples supplied did not contain adequate amount of material retained

on the 19.0 mm sieve. For this reason, participants were advised to perform the test only on coarse aggregate passing the 19.0 mm sieve, using a ratio of 5:1 and to calculate the weighted average by assigning the same percent flat and elongated particles value as the next smaller fraction (i.e., 19.0 mm - 13.2 mm) for 26.5 mm to 19.0 mm that need not be tested.

Seventy-four laboratories reported results for this test in 2013. Two outliers were detected using the iterative technique. The standard deviations of 0.80 and 0.78 obtained in 2013 are significantly higher than the values (0.19 to 0.46) reported in 2011 and 2012. However, the average coefficient of variation of 55.2% obtained in 2013 is significantly lower than the values obtained in 2011(81.8%) and 2012 (64.5%). The majority of points on the scatter plot are located in the first and third quarter indicating significant laboratory bias.

ASTM D 4791 requires that the percent flat and elongated particles results are reported separately for each fraction tested. The precision estimates in this test method are also provided separately for each fraction ranging from 19.0 mm to 12.5 mm, 12.5 mm to 9.5 mm, and 9.5 mm to 4.75 mm. However, the results reported in this study are based on the weighted average calculated using the results of five fractions ranging from 26.5 mm to 4.75.mm. For this reason, a direct comparison of the multi-laboratory variations obtained in this study with that of the precision estimates published by ASTM is not possible.

4. Laboratory Rating System

The laboratory rating system assigns separate overall ratings for each category of laboratories, i.e., low complexity (Production) aggregate laboratories, high complexity (Full Service) Aggregate laboratories, Soil laboratories, and Superpave laboratories. Laboratories must participate in all of the tests that are listed under each category (i.e., Production, Full Service, Soil and Superpave) to assign an overall laboratory rating. Production (CCIL Type C) laboratories are required to carry out wash pass 75 µm, sieve analysis, percent crushed particles, percent asphalt coated particles, and percent flat and elongated particles tests. In addition to these tests, Full Service laboratories (CCIL Type D) must carry out micro-Deval (coarse and fine), freeze-thaw, and/or magnesium sulphate soundness, relative density and absorption (coarse and fine) tests. Soil laboratories are required to carry out particle size analysis, Atterberg limits, and specific gravity of soil tests. Superpave aggregate laboratories are required to perform all four consensus property tests (i.e. uncompacted void content, sand equivalent value, percent fractured particles, and flat and elongated particles).

The rating system gives a maximum rating of 10 for each test, (e.g. 5 for wash pass 75 µm on sample 1.13, plus -5 for wash pass 75 µm on sample 2.13, equals 10 (the negative sign indicating a test result less than the mean is ignored)). See Section 2.1 for explanation of test method ratings. Some tests that are normally reported together are averaged and given a maximum of 10. The relative density and absorption (coarse and fine), one-point Proctor values (maximum wet and dry density, and optimum moisture content), particle size analysis of soils, and Atterberg limits are treated in this manner. Because of the large number of individual test ratings in the sieve analysis results, the ratings are modified so as not to unduly bias the overall balance between various tests. The ratings for each sieve size are added and then divided by eleven coarse and fine sieves for which results were reported, and multiplied by 3 to give a laboratory rating with a maximum of 30 for this test. Individual laboratory ratings are calculated by adding the ratings of each test in the appropriate lab category (i.e. Production, Full Service, Soil, or Superpave) and converting the sum to a percentage of the maximum available rating for the category. The spread of laboratory ratings for Production, Full Service, Soil, and Superpave laboratories are given in the form of histograms in Figures 2 to 5. The rating system for "Full Service Laboratory" (Type D) shows that 52% of the participating laboratories in 2013 obtained a rating higher than 90 and, in the case of consensus property tests (Superpave), 62% of the participants obtained an overall laboratory rating higher than 90. The laboratory rating system data is reported in the Appendices F1, F2, F3, and F4.

Laboratory ratings for each category are given to participants in the covering letter accompanying the individual laboratory results. A poor or good rating for a laboratory in one year is an indication of how that laboratory performed in the proficiency study, and may not be a reflection of how the laboratory performs year round. A consistently poor rating over two or more years may be cause for serious concern.

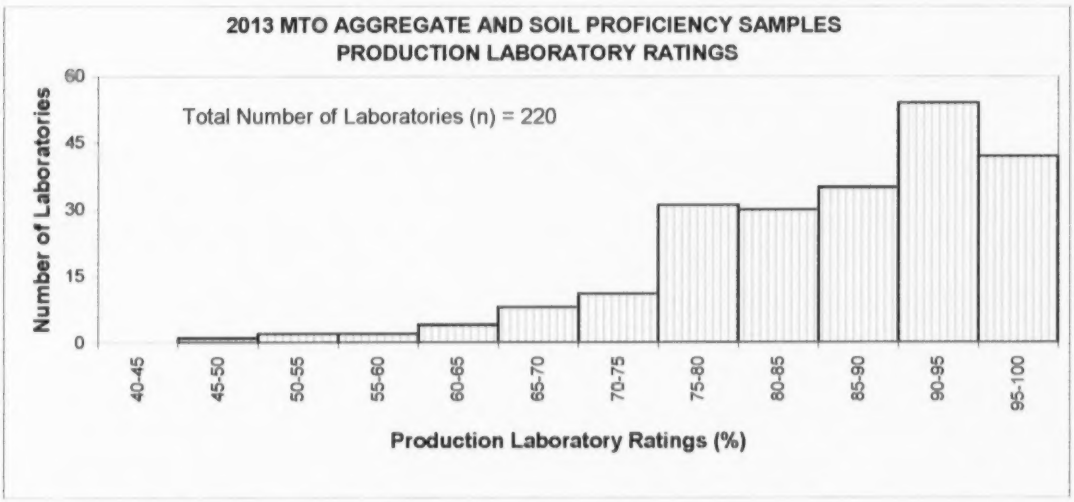


Figure 2. Production Laboratory Ratings

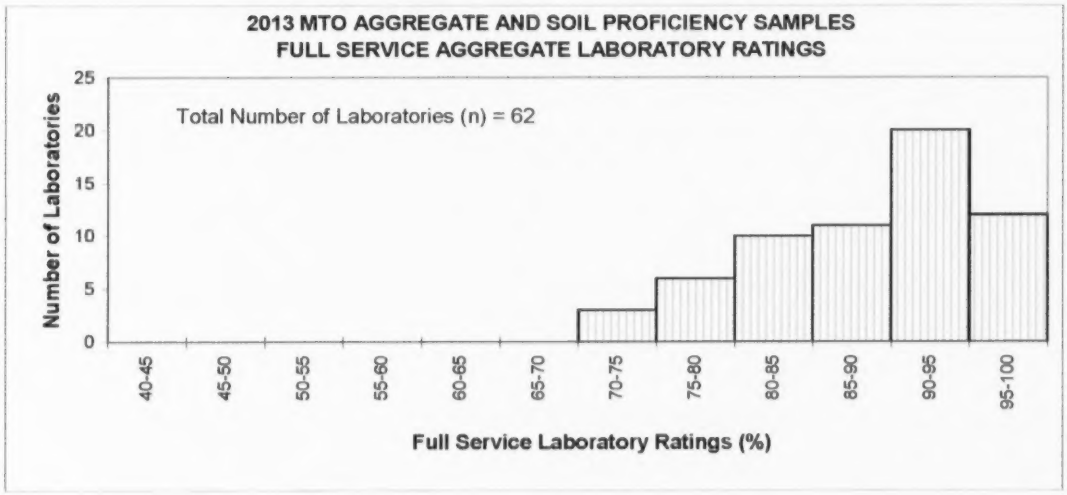


Figure 3. Full Service Laboratory Ratings

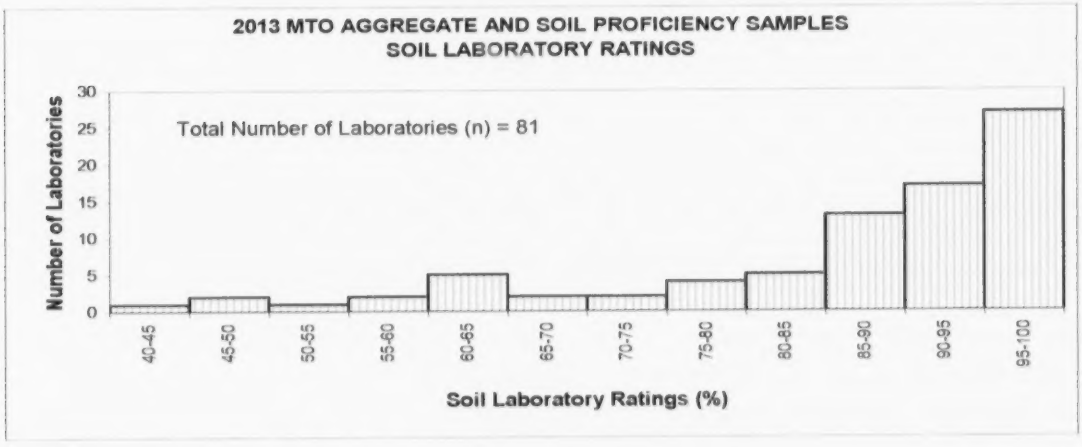


Figure 4. Soil Laboratory Ratings

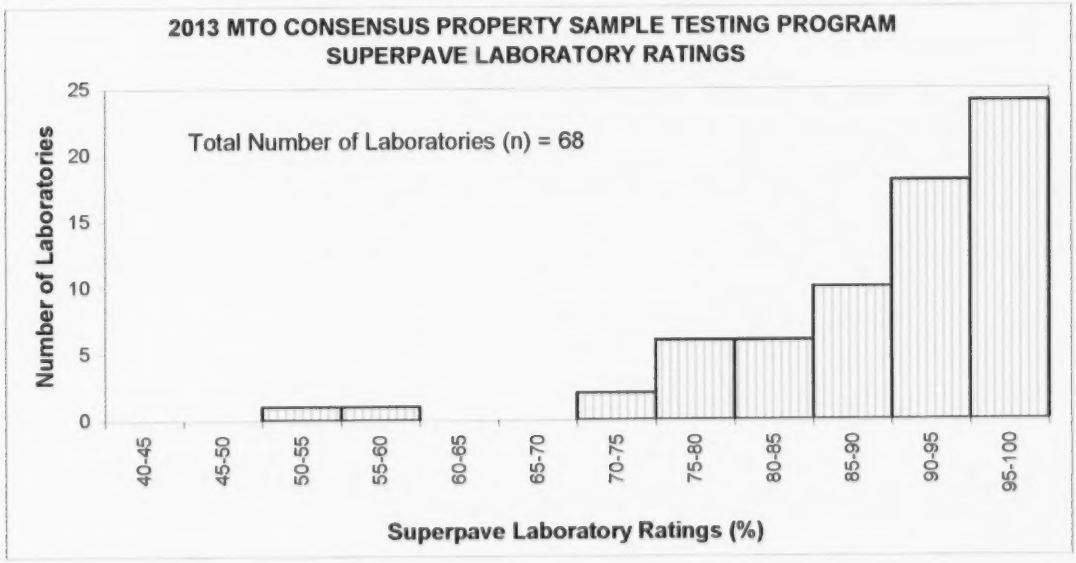


Figure 5. Superpave Laboratory Ratings

5. Conclusions

The method of proficiency sample preparation employed by MTO resulted in almost identical mean gradation values for samples 1.13 and 2.13. The differences in mean, as well as in the standard deviations between pairs of samples for both coarse and fine sieves are almost negligible. Based on the results, it may be concluded that the sample preparation method employed is very effective and capable of producing a uniform and nearly identical material at reasonable cost.

The majority of the aggregate and soil test results of the 2013 Aggregate and Soil Proficiency Sample Testing Program compare favourably with the results of previous studies. In some cases, the variations show noticeable improvement over previous years' results and the precision estimates of those tests where MTO or ASTM precision statements are available. The scatter diagrams for the majority of the aggregate tests show either random variation or a combination of random variation and laboratory bias for some laboratories.

Two hundred and twenty of the laboratories that participated in the aggregate tests are CCIL Type C (Production) certified, and sixty-two of those are also CCIL Type D (Full Service) certified. CCIL inspects the certified laboratories for quality control procedures, ability of technicians, and condition and calibration of the equipment at about eighteen month intervals. The performance of laboratories in most of the aggregate tests (Type C and Type D) is consistent with the results in the past and a large number of these tests show improvement in multi-laboratory variation over the established precision estimates. The improvements noted may be due to the on-site laboratory inspection by CCIL at regular intervals, proficiency sample testing, and due to an increased awareness of the importance of proper testing and quality control procedures implemented by CCIL.

Eighty-one laboratories participated in all three soil tests. The variations found in 2013 for the soil tests are consistent with that of the values reported in the last three years' studies, but the scatter diagrams of all three tests still show strong laboratory biases. The results of soil tests are significantly influenced by operator skills, testing environment, and the condition and calibration of the equipment. Thirty-four of the Eighty-one laboratories that participated in the soil tests are on the MTO Vendors List. Most of the laboratories that are on the MTO Vendors List were inspected by MTO staff more than six to eight years ago and only a few re-inspections[8] have been done to date.

Sixty-eight laboratories participated in all four Superpave consensus property tests. The results of 2013 compare favourably with the results of past three years. However, the multi-laboratory precisions obtained in 2013, except uncompacted void content, show improvement over the ASTM precision estimates. As in the past, the scatter diagrams for all four tests show strong laboratory biases. It is expected that the quality control program implemented by CCIL will bring about improvements in multi-laboratory variations.

8 To arrange an inspection of your Soil Laboratory, please contact Mark Vasavithasan, Soils and Aggregates Section, Ministry of Transportation, phone (416) 235-4901, fax (416) 235-4101, Mark.Vasavithasan@ontario.ca.

6. Recommendations

Although, there are improvements in the multi-laboratory variations over the precision estimates established by ASTM and MTO, strong laboratory biases still remain in few of the aggregate tests and all of the soil and consensus property test procedures. The laboratories that were identified as outliers should examine their quality control practices, the condition and calibration of equipment, testing procedures, and skills of the technicians. Laboratories must investigate the causes and prepare corrective action reports as required by the quality system whenever a rating of 2 or less is obtained for each sample in a test.

The results of the 2013 MTO Aggregate and Soil Proficiency Sample Testing Program suggest that most laboratories have performed satisfactorily. Laboratories that obtained relatively low ratings must focus on quality control practices, operator training, standardization and calibration of equipment, and improvements to laboratory environment in order to improve their performance.

For all of the tests that were included in this study, the equipment to be used is regulated by the test method itself. A good state of equipment maintenance, repair, and correct calibration is required in order to achieve improvements. It is hoped that the mandatory Quality System implemented by CCIL will encourage laboratories to conduct a review of their internal quality control practices to ensure that they have the correct equipment and properly trained technicians. Laboratories will find that a well-documented and regular program of internal inspection, calibration, and testing of control or reference samples is beneficial to maintaining a high level of confidence in their results.

7. Acknowledgments

The authors would like to acknowledge Bob Gorman of the Soils and Aggregates Section for the selection of aggregate materials for the 2013 proficiency sample testing program. We would also like to thank the many laboratory staff, students and engineers-in-training of the Materials Engineering and Research Office for their dedicated assistance in preparing more than 2290 individual samples, from almost 50 tonnes of aggregate and soil material, for distribution to the program participants.

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Appendix A: Glossary of Terms

Acceptable difference between two results (difference two-sigma limit (d2s)) as an index of precision is the maximum acceptable difference between two results obtained on test portions of the same material tested by two different laboratories. The index, d2s, is the difference between two individual test results that would be equalled or exceeded in only one case in twenty in the normal and correct operation of the method. The index is calculated by multiplying the multi-laboratory standard deviation (1s) by the factor $2\sqrt{2}$ (2.83).

Accuracy refers to the degree of mutual agreement between a set of measurements with an accepted reference or 'true value'. This 'true' or reference value can be an assigned value arrived at by actual experiments.

Bias of a measurement process is a consistent and systematic difference between a set of test results derived from using the process and an accepted reference value of the property being measured. For the majority of aggregate and soil tests, there is no acceptable reference material, so bias is impossible to compute.

Coefficient of Variation expresses the standard deviation as a percentage of the mean, where:

$$C.V. = \frac{\text{std dev}}{\text{mean}} \times 100$$

Critical Value is that value of the sample criterion which would be exceeded by chance with some specified probability (significance level) on the assumption that all the observations did indeed constitute a random sample from a common system of causes.

MAIDB refers to Mineral Aggregate Inventory Data Bank of the Ministry of Transportation.

Median is synonymous with the middle and the **sample median** is the middle value of a list of test results when the observations are ordered from smallest to largest in magnitude. After rearranging the observations in increasing order (from most negative to most positive), the **sample median** is the *single middle value* in the ordered list, if n is odd, or the *average of the two middle values* in the ordered list, if n is even, where n equals the number of observations.

Multi-laboratory precision is a quantitative estimate of the variability of a large group of individual test results when each test has been made in a different laboratory and every effort has been made to make test portions of the material as nearly identical as possible. Under normal circumstances, the estimates of the one-sigma limit (1s) for multi-laboratory precision are usually larger than those for single-operator precision because different operators and different equipment are being used in different laboratories.

Outlier is a measurement that, for a specific degree of confidence, is not part of the population. In this study, an outlier is generally three or more standard deviations from the

mean, giving a confidence level of ninety-nine percent. If a laboratory test result is classified as an outlier, it means that something went wrong either with the sample or in the laboratory.

Precision refers to the degree of mutual agreement between individual measurements on the same material. In other words, precision is a measure of how well the individual test results of a series agree with each other.

Sample mean or average is the sum of all observations divided by the total number of observations.

Single operator precision (one-sigma limit (1s)) indicates the variability, as measured by the deviations above and below the average, of a large group of individual test results when the tests have been made on the same material by a single operator using the same apparatus in the same laboratory over a relatively short time.

Standard deviation is the most usual measure of the dispersion of observed values or results expressed as the positive square root of the variance.

Variance is a measure of the squared dispersion of observed values or measurements expressed as a function of the sum of the squared deviations from the population mean or sample average.

Appendix B1: List of Participants

2013 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Stephen Senior (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
A. L. Blair Construction Limited Moose Creek, ON Mr. Justin Blair Tel: 613 538-2271	✓	✓				✓	✓							✓				
AGS Associates Inc. Scarborough, ON Mr. Amjed Siddiqui Tel: 416 299-3655	✓	✓		✓	✓	✓	✓				✓	✓		✓	✓	✓	✓	✓
Alston Associates Inc. Toronto, ON Mr. Jonathan Bond Tel: 905 474-5265	✓	✓				✓	✓							✓	✓	✓	✓	✓
AME - Materials Engineering Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
AME - Materials Engineering Ottawa, ON Mr. Harrison Smith Tel: 613 726-3039	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
AME - Materials Engineering (24-165) Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-270) Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-271) Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-297) Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-298) Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-384) Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-911) Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-912) Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AMEC Earth & Environmental Ltd. Scarborough, ON Mr. Mohammadsarif Sufi Tel: 416 751-6565	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓

2013 Participants List

Ministry of Transportation
Aggregate and Soil
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Testing Program

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Mark Vasavithasan (416) 235-4901, or
Stephen Senior (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
AMEC Earth & Environmental Ltd. Hamilton, ON Mr. John Balinski Tel: 905 312-0700	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd. Cambridge, ON Ms. Tammy Hawkins Tel: 519 650-7100	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd. Sarnia, ON Mr. Geoff Collier Tel: 519 337-5409	✓	✓				✓	✓							✓	✓			
AMEC Earth & Environmental Ltd. Tecumseh, ON Mr. Justin Palmer Tel: 519 735-2499	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd. Thorold, ON Mr. Andrew Markov Tel: 905 687-6616	✓	✓				✓	✓							✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd. – PN2 Hamilton, ON Mr. Martin Little Tel: 905 312-0700								✓	✓									
AMEC Earth & Environmental Ltd. – PN4 Hamilton, ON Mr. Jesse Stickless Tel: 905 312-0700								✓	✓									
AMEC Earth & Environmental Ltd. – PN5 Hamilton, ON Ms. Heather Racher Tel: 905 312-0700								✓	✓									
AMEC Earth & Environmental Ltd. – PN7 Hamilton, ON Ms. Jennifer McKenna Tel: 905 312-0700								✓	✓									
Bernt Gilbertson Enterprises Ltd. Richards Landing, ON Mr. Scott Eddy Tel: 705 246-2076	✓	✓				✓	✓							✓				
BOT Construction Oakville, ON Mr. Vicks Sellathurai Tel: 905 827-3250	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
BOT Construction - Mobile Oakville, ON Mr. Vicks Sellathurai Tel: 905 827-3250	✓	✓				✓	✓							✓	✓			
Bruno's Contracting (Thunder Bay) Ltd. Thunder Bay, ON Mr. Silvio DiGregorio Tel: 807 623-1855	✓	✓				✓	✓							✓	✓			
C. Villeneuve Construction – Mobile 1 Hearst, ON Mr. Charles Harris Tel: 705 372-1838	✓	✓		✓		✓	✓							✓	✓			
C. Villeneuve Construction – Mobile 2 Hearst, ON Mr. Charles Harris Tel: 705 372-1838	✓	✓				✓	✓							✓	✓			
C. Villeneuve Construction – Mobile 3 Hearst, ON Mr. Charles Harris Tel: 705 372-1838	✓	✓				✓	✓							✓	✓			
C.T. Soil & Materials Testing Inc. Windsor, ON Mr. Thomas O'Dwyer Tel: 519 966-8863	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓

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Caledon Sand & Gravel Ltd. Caledon Village, ON Mr. Dean Glenn Tel: 905 857-3500	✓	✓				✓	✓							✓				
Cambium Inc. Peterborough, ON Mr. Wayne Rayfuse Tel: 705 742-7900	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Capital Paving Inc. Guelph, ON Mr. Mark Latyn Tel: 519 822-4511	✓	✓				✓	✓							✓	✓			
CBM Aggregates Cambridge, ON Mr. Mike Smith Tel: 519 239-4743	✓	✓				✓	✓							✓				
CBM Aggregates Brighton, ON Mr. Mike Smith Tel: 519 319-8409	✓	✓				✓	✓							✓				
CBM Aggregates London, ON Mr. Mike Smith Tel: 519 240-8410	✓	✓				✓	✓							✓				
CBM Aggregates Sunderland, ON Mr. Mike Smith Tel: 519 319-8409	✓	✓				✓	✓							✓				
CBM Aggregates Westwood, ON Mr. Mike Smith Tel: 519 319-8409	✓	✓				✓	✓				✓	✓		✓				
CCI Group Inc. Woodbridge, ON Mr. M. Sukhandan Tel: 905 856-5200	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Chung & Vander Dollen Engineering Limited, Kitchener, ON Mr. William Evans Tel: 519 742-8979	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
CMT Engineering Inc. St. Clements, ON Mr. Nathan Love Tel: 519 699-5775	✓	✓				✓	✓							✓	✓			
COCO Paving Inc. Belleville, ON Mr. Tom Woodcock Tel: 613 962-3461	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓		✓	
COCO Paving Inc. Ottawa, ON Mr. Brad Gooderham Tel: 613 907-7283	✓	✓		✓		✓	✓				✓	✓		✓				
COCO Paving Inc. Toronto, ON Mr. Andrew Pahalan Tel: 416 347-3590	✓	✓		✓		✓	✓							✓				
COCO Paving Inc. Windsor, ON Mr. Ishaq Syed Tel: 519 948-7133	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Coffey Geotechnics Inc. Toronto, ON Mr. Rizwan Bajwa Tel: 416 213-1255	✓	✓				✓	✓							✓	✓	✓	✓	✓
Colacem Canada L'Original, ON Mr. Shu Yang Tel: 819 242-4312	✓	✓				✓	✓				✓	✓		✓				

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Concrete Materials Lab, Dept. of Engineering, U. of Toronto Dr. R. D. Hooton Tel: 416 946-5496													✓					
Construction Testing Asphalt Lab Ltd. Cambridge, ON Mr. Peter Lung Tel: 519 622-7023	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Cornwall Gravel Company Limited Cornwall, ON Ms. Billie-Gail Macfarlane Tel: 613 930-3530	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓		✓	
Corporation of the County of Grey Chatsworth, ON Mr. Gregory Pell Tel: 519 376-7339	✓	✓				✓	✓							✓				
Cox Construction Limited Guelph, ON Mr. Andrew Smith Tel: 519 824-6570	✓	✓		✓		✓	✓							✓	✓			
Cruickshank Construction Ltd. Elginburg, ON Mr. Tim Bilton Tel: 613 536-9112	✓	✓		✓	✓	✓	✓				✓	✓		✓				
Cruickshank Construction Ltd. - Mobile Kemptville, ON Mr. Tim Bilton Tel: 613 258-9111	✓	✓				✓	✓							✓				
D. Crupi & Sons Limited Toronto, ON Mr. P.Kandasaami Tel: 416 291-1986	✓	✓		✓		✓	✓							✓				
D. F. Elliott Consulting Engineering New Liskeard, ON Mr. Brad Gilbert Tel: 705 647-6871	✓	✓				✓	✓							✓	✓			
Danford Construction Madoc, ON Mr. Al Danford Tel: 613 473-2468	✓	✓				✓	✓							✓				
Davroc Testing Laboratories Inc. Brampton, ON Mr. Sal Fasullo Tel: 905 792-7792	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
DBA Engineering Limited Cambridge, ON Mr. Andy Burleigh Tel: 905 851-0090	✓	✓				✓	✓							✓	✓			
DBA Engineering Limited Vaughan, ON Mr. Andy Burleigh Tel: 905 851-0090	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DBA Engineering Limited – PN2 Vaughan, ON Mr. Nick Sibillia Tel: 905 851-0090								✓										
DBA Engineering Limited – PN3 Vaughan, ON Mr. Alhua Liang Tel: 905 851-0090								✓										
DBA Engineering Limited – PN4 Vaughan, ON Mr. Kevin Jackson Tel: 905 851-0090								✓										
DBA Engineering Ltd. Kingston, ON Mr. Mark McClelland Tel: 613 389-1781	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓

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Department of Civil Engineering Ryerson University, Toronto Dr. Medhat Shehata Tel: 416 979-5000													✓					
District Municipality of Muskoka Bracebridge, ON Mr. Dave Wood Tel: 705 645-6764	✓	✓				✓	✓							✓	✓	✓	✓	
Drain Bros Excavating Ltd. Lakefield, ON Mr. Elton Neuman Tel: 705 639-2301	✓	✓				✓	✓				✓	✓		✓	✓			
DST Consulting Engineers Inc. Kenora, ON Mr. Neil Johnson Tel: 807 468-2349	✓	✓				✓	✓							✓	✓	✓	✓	
DST Consulting Engineers Inc. Thunder Bay, ON Dr. Myint Win Bo Tel: 807 623-2929	✓	✓	✓	✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
DST Consulting Engineers Inc. Ottawa, ON Mr. George Thomas Tel: 613 247-2425	✓	✓				✓	✓							✓				
Dufferin Aggregates Acton, ON Ms. Kelly Mercer Tel: 416 453-3268	✓	✓				✓	✓							✓				
Dufferin Aggregates Blair, ON Mr. Gord Taylor Tel: 905 308-5324	✓	✓				✓	✓							✓				
Dufferin Aggregates Cayuga, ON Mr. Gord Taylor Tel: 905 308-5324	✓	✓		✓		✓	✓			✓	✓	✓		✓				
Dufferin Aggregates Dundas, ON Mr. Gord Taylor Tel: 905 308-5324	✓	✓				✓	✓							✓				
Dufferin Aggregates Milton, ON Ms. Kelly Mercer Tel: 416 453-3268	✓	✓				✓	✓							✓				
Dufferin Aggregates Orono, ON Ms. Kelly Mercer Tel: 416 453-3268	✓	✓				✓	✓							✓				
Dufferin Aggregates Cambridge, ON Mr. Gord Taylor Tel: 905 308-5324	✓	✓				✓	✓							✓				
Dufferin Construction Limited - Cayuga Cayuga, ON Mr. Ronald Abdul Tel: 905 827-5750	✓	✓		✓		✓	✓							✓	✓			
Dufferin Construction Limited - Mobile 1 Oakville, ON Mr. Ronald Abdul Tel: 905 827-5750	✓	✓				✓	✓							✓				
Dufferin Construction Limited - Mobile 2 Oakville, ON Mr. Ronald Abdul Tel: 905 827-5750	✓	✓				✓	✓							✓				
Dufferin Construction Limited - Mobile 3 Oakville, ON Mr. Ronald Abdul Tel: 905 827-5750	✓	✓				✓	✓							✓				

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Dufferin Construction Ltd. (QC) Oakville, ON Mr. Ronald Abdul Tel: 905 827-5750	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
E.C. King Contracting Owen Sound, ON Mr. Lance Elliott Tel: 519 376-6140	✓	✓				✓	✓							✓	✓			
Engtec Consulting Inc. Vaughan, ON Mr. Salman Bhutta Tel: 905 856-2988	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Esko Savela & Son Contracting Inc. Shuniah, ON Mr. Craig Baumenn Tel: 807 983-2097	✓	✓				✓	✓							✓				
exp Services Inc. Timmins, ON Mr. Jason Ferrigan Tel: 705 268-4351	✓	✓				✓	✓							✓				
exp Services Inc. Brampton, ON Mr. Ammanuel Yousif Tel: 905 793-9800	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
exp Services Inc. London, ON Mr. David Speller Tel: 519 963-3000	✓	✓				✓	✓				✓	✓		✓	✓	✓	✓	✓
exp Services Inc. Oldcastle, ON Mr. David Speller Tel: 519 963-3000	✓	✓				✓	✓							✓	✓			
exp Services Inc. Hamilton, ON Mr. Ashraf Abass Tel: 905 573-4000	✓	✓				✓	✓							✓	✓	✓	✓	
exp Services Inc. Sudbury, ON Mr. Rob Ferguson Tel: 705 674-9681	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
exp Services Inc. Ottawa, ON Mr. Ismail M. Taki Tel: 613 723-2886	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
exp Services Inc. Thunder Bay, ON Mr. Darryl Kelly Tel: 807 623-9495	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓		✓	
exp Services Inc. Barrie, ON Mr. Leigh Knegt Tel: 705 734-6222	✓	✓				✓	✓							✓	✓	✓	✓	✓
Fermar Construction Limited Rexdale, ON Mr. W. Francescantonio Tel: 416 675-3550	✓	✓		✓		✓	✓							✓	✓			
Fowler Construction Company Bracebridge, ON Mr. Ross Elliott Tel: 705 644-4037	✓	✓		✓		✓	✓				✓	✓		✓	✓			
Fowler Construction Company – Mobile Bracebridge, ON Mr. Ross Elliott Tel: 705 644-4037	✓	✓		✓		✓	✓							✓	✓			
G. Tackaberry & Sons Construction Co. Ltd., Athens, ON Mr. Paul Rodgers Tel: 613 924-2634	✓	✓				✓	✓							✓	✓			

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Gamsby and Mannerow Limited Owen Sound, ON Mr. Derek Brewster Tel: 519 376-1805	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Gazzola Paving Ltd. Etobicoke, ON Mr. Solomon. Andualem Tel: 416 675-9803	✓	✓				✓	✓							✓				
Genivar Peterborough, ON Ms. Kelly Whitney Tel: 705 743-6850	✓	✓				✓	✓							✓	✓	✓	✓	✓
Geo Terre Limited Brampton, ON Mr. Julian Murillo Tel: 905 455-5666	✓	✓				✓	✓							✓	✓	✓	✓	
Geo-Logic Inc. Peterborough, ON Mr. Matt Rawlings Tel: 705 749-3317	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Geo-Logic Inc. Oshawa, ON Mr. Matt Rawlings Tel: 705 749-3317	✓	✓				✓	✓							✓	✓			
Geo-Logic Inc. Pembroke, ON Mr. Sheldon Thoma Tel: 613 735-8361	✓	✓				✓	✓							✓	✓		✓	
Golder Associates Ltd. Barrie, ON Mr. Rick Watson Tel: 705 722-4492	✓	✓				✓	✓							✓	✓	✓	✓	✓
Golder Associates Ltd. Cambridge, ON Mr. Jodi Norris Tel: 519 620-1222	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Golder Associates Ltd. Markham, ON Mr. Albert Lam Tel: 905 475-5591	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Golder Associates Ltd. London, ON Mr. Chris Sewell Tel: 519 652-0099	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Golder Associates Ltd. Mississauga, ON Ms. Mariana Manojlovic Tel: 905 567-4444	✓	✓				✓	✓							✓	✓	✓	✓	✓
Golder Associates Ltd. Ottawa, ON Mr. Chris Mangione Tel: 613 592-9600	✓	✓		✓		✓	✓	✓						✓	✓	✓	✓	✓
Golder Associates Ltd. Sudbury, ON Ms. Sylvie LaPorte Tel: 705 524-6861	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Golder Associates Ltd. Whitby, ON Mr. Jeremy Rose Tel: 905 723-2727	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Golder Associates Ltd. Windsor, ON Mr. Roy Walsh Tel: 519 250-3733	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Golder Associates Ltd. Burnabay, B.C. Ms. Lily Hu Tel: 604 592-3259	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

2013 Participants List

Ministry of Transportation
Aggregate and Soil
Proficiency Sample
Testing Program

For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Stephen Senior (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
Graham Brothers Construction Limited Brampton, ON Mr. Greg Thompson Tel: 905 453-1200	✓	✓		✓		✓	✓				✓	✓		✓	✓		✓	
Greenwood Aggregates Amaranth, ON Mr. Andrew Raymond Tel: 519 940-6844	✓	✓		✓		✓	✓			✓	✓	✓		✓			✓	
Harold Sutherland Construction Ltd. Kemble, ON Mr. Roland Leigh Tel: 519 376-3506	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓			
Hatch Ltd. Niagara Falls, ON Mr. Ralph Serluca Tel: 905 374-5200	✓	✓													✓	✓	✓	✓
Holcim Canada Inc. Etobicoke, ON Mr. G. Julio-Betancourt Tel: 416 744-2206	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓			✓	
Holcim Canada Inc. Etobicoke, ON Mr. Kim Ripper 416 744-2206								✓										
Houle Chevrier Engineering Limited Carp, ON Mrs. Krystle Smith Tel: 613 836-1422	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Huron Construction Co. Ltd. Chatham, ON Mr. David Smith Tel: 519 354-0170	✓	✓				✓	✓							✓				
Inspec-sol Inc. St. Catharines, ON Mr. Wayne Russell Tel: 905 682-0510	✓	✓				✓	✓							✓	✓	✓	✓	
Inspec-sol Inc. Kingston, ON Mr. Mark Patterson Tel: 613 389-9812	✓	✓				✓	✓							✓	✓			
Inspec-Sol Inc. Mississauga, ON Mr. Raj Kadia Tel: 905 712-4771	✓	✓				✓	✓							✓	✓	✓	✓	✓
Inspec-sol Inc. Ottawa, ON Mr. Daniel Boateng Tel: 613 727-0895	✓	✓				✓	✓							✓	✓			
Inspec-Sol Inc. Waterloo, ON Mr. Bruce Polan Tel: 519 725-9328	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Interpaving Asphalt & Aggregate Supply Ltd. Sudbury, ON Ms. Ashley Edwards Tel: 705 694-6210	✓	✓		✓		✓	✓	✓			✓	✓		✓	✓		✓	
Intratech Engineering Laboratories Inc. Scarborough, ON Mr. Frank Miles Tel: 416 754-2077	✓	✓		✓	✓	✓	✓			✓				✓	✓	✓	✓	✓
J & P Leveque Bros. Ltd. - Mobile 616 Bancroft, ON Mr. Shawn Fransky Tel: 613 332-5533	✓	✓				✓	✓				✓	✓		✓	✓		✓	
J & P Leveque Bros. Ltd. – Mobile 617 Bancroft, ON Mr. Shawn Fransky Tel: 613 332-5533	✓	✓				✓	✓				✓	✓		✓	✓		✓	

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John D. Paterson & Associates Ottawa, ON Mr. Stephen Walker Tel: 613 226-7381	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
John D. Paterson & Associates North Bay, ON Mr. Shawn Nelson Tel: 707 472-5331	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
K. J. Beamish Construction - Mobile 1 King City, ON Mr. Chad Henderson Tel: 905 833-4666	✓	✓				✓	✓							✓	✓			
K. J. Beamish Construction - Mobile 2 King City, ON Mr. Chad Henderson Tel: 905 833-4666	✓	✓				✓	✓							✓	✓			
K.J. Beamish Construction King City, ON Mr. Chad Henderson Tel: 905 833-4666	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓		✓	
Lafarge Canada Orono, ON Mr. Frances Clements Tel: 905 983-9260	✓	✓				✓	✓							✓				
Lafarge Canada – Mobile 434 Barrie, ON Ms. Sarah Brown Tel: 705 623-4166	✓	✓				✓	✓							✓				
Lafarge Canada - Orillia Lab Barrie, ON Ms. Sarah Brown Tel: 705 623-4166	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Brechin, ON Ms. Christine Crumbie Tel: 705 484-5225	✓	✓				✓	✓				✓	✓		✓				
Lafarge Canada Inc. Dundas, ON Mr. Chris Thomas Tel: 905 977-7363	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓		✓	
Lafarge Canada Inc. Cambridge, ON Mr. Michael Koch Tel: 519 319-9128	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Fonthill, ON Mr. Michael Koch Tel: 905 522-7735	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Hamilton, ON Mr. Michael Koch Tel: 905 979-3107	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓			✓	
Lafarge Canada Inc. London, ON Mr. Michael Koch Tel: 519 319-9128	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Paris, ON Mr. Michael Koch Tel: 905 522-7735	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Meldrum Bay, ON Mr. Jeff Middleton Tel: 705 283-3011	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Ottawa, ON Mr. Fred Douglas Tel: 613 830-3060	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓		✓	

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Lafarge Canada Inc. Stouffville, ON Ms. Christine Crumbie Tel: 905 640-5883	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Caledon, ON Mr. Chris Thomas Tel: 519 927-1113	✓	✓				✓	✓							✓				
Lafarge Canada Inc. – Pt. Anne Quarry Belleville, ON Mr. Jason Malcolm Tel: 613 813-4857	✓	✓				✓	✓							✓				
Lafarge Construction Materials Ltd. Brockville, ON Mr. Paul Arkeveld Tel: 613 349-7422	✓	✓				✓	✓			✓	✓	✓		✓				
Lafarge Construction Materials Ltd. Glenburnie, ON Mr. Paul Arkeveld Tel: 613 349-7422	✓	✓				✓	✓							✓				
Landtek Limited Hamilton, ON Mr. Paul Anderson Tel: 905 383-3733	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	✓
Lavis Contracting Co. Limited Clinton, ON Mr. Allan Gardner Tel: 519 482-3694	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓		✓	
Law Engineering (London) Inc. London, ON Mr. Joe Law Tel: 519 680-9991	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
LVM Inc. Kitchener, ON Mr. Jason Taylor Tel: 519 741-1313	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
LVM Inc. Branford, ON Mr. David Baillie Tel: 519 720-0078	✓	✓				✓	✓							✓	✓	✓	✓	
LVM Inc. London, ON Ms. Amy Helle Tel: 519 685-6400	✓	✓				✓	✓							✓	✓	✓	✓	
LVM Inc. Stratford, ON Ms. Vicki Gravelle Tel: 519 273-0101	✓	✓				✓	✓							✓	✓	✓	✓	
LVM Inc. Toronto, ON Mr. Dawit Amar Tel: 416 213-1060	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
LVM/Merlex North Bay, ON Mr. J. P. Duhaime Tel: 705 476-2550	✓	✓				✓	✓							✓	✓	✓	✓	✓
McAsphalt Engineering Services Toronto, ON Mr. Michael Esenwa Tel: 416 281-8181	✓	✓		✓		✓	✓							✓	✓			
Mill-Am Corporation - Mobile 890901 Oldcastle, ON Mr. Cesare Di Cesare Tel: 519 945-7441	✓	✓				✓	✓							✓	✓			
Miller Northwest Limited – Mobile 120601 Dryden, ON Ms. Melodie Asselin Tel: 807 223-2844	✓	✓				✓	✓							✓	✓			

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Miller Northwest Limited - Mobile 942012 Dryden, ON Ms. Melodie Asselin Tel: 807 223-2844	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Limited Markham, ON Ms. Carla Hariprashad Tel: 905 475-6660	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓		✓	
Miller Paving Limited Port Colborne, ON Ms. Melissa Slipak Tel: 905 834-9227	✓	✓		✓		✓	✓				✓	✓		✓	✓			
Miller Paving Limited Whitby, ON Ms. Carla Hariprashad Tel: 905 655-3889		✓				✓	✓							✓				
Miller Paving Limited - Carden Lab Brechin, ON Ms. Christina Watts Tel: 705 484-1101	✓	✓				✓	✓							✓				
Miller Paving Limited – Carden Mobile Brechin, ON Ms. Christina Watts Tel: 705 484-1101	✓	✓				✓	✓							✓				
Miller Paving Limited - Mobile 8661 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓				✓	✓							✓	✓			
Miller Paving Limited - Patterson Quarry Utterson, ON Ms. Christina Watts Tel: 705 385-0249	✓	✓				✓	✓							✓				
Miller Paving Ltd. – Mobile 60853 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Ltd. – Mobile 8660 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓				✓	✓							✓	✓			
Miller Paving Ltd.- Materials Research Lab Gormley, ON Ms. Amma Wakefield Tel: 905 726-9518	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	
Miller Paving Northern - Mobile 1084 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Northern - Mobile 1254 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓		✓		✓	✓				✓	✓		✓	✓			
Miller Paving Northern - Mobile 50612 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓				✓	✓							✓	✓			
Miller Paving Northern - Mobile 60889 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓		✓		✓	✓							✓	✓			
Ministry of Transportation Downsview, ON Mr. Stephen Senior Tel: 416 235-3734	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ministry of Transportation – PN1 Downsview, ON Mr. Kliton Verli Tel: 416 235-3734								✓										

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Ministry of Transportation – PN2 Downsview, ON Mr. Stephen Senior Tel: 416 235-3734								✓										
MNA Engineering Limited Scarborough, ON Mr. Peter Balendran Tel: 416 757-8882	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Nasiruddin Engineering Limited Mississauga, ON Mr. Shakeel Nasiruddin Tel: 905 565-9595	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Nelson Aggregate Co. Beamsville, ON Mr. Shawn Warkholdt Tel: 905 563-8226	✓	✓				✓	✓							✓				
Nelson Aggregate Co. Burlington, ON Mr. Michael Rook Tel: 905 335-5250	✓	✓				✓	✓							✓				
Nelson Aggregate Co. Orillia, ON Mr. Chris Roote Tel: 705 325-2264	✓	✓				✓	✓							✓				
Peto MacCallum Limited Barrie, ON Mr. Andrew Jones Tel: 705 734-3900	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Peto MacCallum Limited Hamilton, ON Mr. Amjad Khan Tel: 905 561-2231	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Peto MacCallum Limited Kitchener, ON Mr. Tony Smith Tel: 519 893-7500	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Peto MacCallum Limited Toronto, ON Mr. Geoffrey Uwimana Tel: 416 785-5110	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Pinchin Environmental Sault Ste. Marie, ON Mr. Wesley Tabaczuk Tel: 705 575-9207	✓	✓				✓	✓							✓	✓	✓	✓	✓
Pioneer Construction Inc. Sault Ste. Marie, ON Mrs. Shelley Geiling Tel: 705 541-2280	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓			
Pioneer Construction Inc. Copper Cliff, ON Mr. David Pilkey Tel: 705 693-1363	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓			
Pioneer Construction Inc. Thunder Bay, ON Mr. Tony Fazio Tel: 807 345-2338	✓	✓		✓		✓	✓							✓	✓			
Port Colborne Quarries Inc. Port Colborne, ON Mr. Tim Cassibo Tel: 905 834-3647	✓	✓				✓	✓							✓				
Preston Sand & Gravel Kitchener, ON Mr. Matthew Bell Tel: 519 242-0902	✓	✓				✓	✓							✓				
R. W. Tomlinson Limited Ottawa, ON Mr. Paul Charbonneau Tel: 613 822-0543	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓		✓	✓

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R.S Wilson Materials Testing & Inspection Sault Ste. Marie, ON Mr. Robert Wilson Tel: 705 759-2881	✓	✓		✓		✓	✓							✓	✓			
Regional Municipality of Durham Whitby, ON Mr. Joeman Ng Tel: 905 655-3344	✓	✓				✓	✓							✓	✓			
Sarafinchin Associates Limited Rexdale, ON Mr. Scott Jeffrey Tel: 416 674-1770	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Shaba Testing Services Limited Kirkland Lake, ON Mr. Lad Shaba Tel: 705 567-4187	✓	✓				✓	✓							✓	✓			
Shaheen Peaker Thompson Limited Oshawa ON Mr. Dave Thompson Tel: 905 436-9028	✓	✓		✓	✓	✓	✓			✓				✓	✓	✓	✓	✓
Smelter Bay Aggregates Inc. Thessalon, ON Mr. Jordan Bird Tel: 705 842-2597	✓	✓				✓	✓							✓				
Soil Engineers Limited Scarborough, ON Mr. S. Sanjeevan Tel: 416 754-8515	✓	✓				✓	✓							✓	✓	✓	✓	✓
SPL Consultants Limited Markham, ON Mr. Jordan Gadjanov Tel: 905 475-0065	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
SPL Consultants Limited Nepean, ON Mr. Chris Hendry Tel: 613 228-0065	✓	✓				✓	✓	✓						✓	✓	✓	✓	✓
SPL Consultants Limited Vaughan, ON Mr. Andrew Mendonca Tel: 905 856-0065	✓	✓				✓	✓							✓	✓	✓	✓	✓
St Lawrence Testing & Inspection Co. Ltd. Cornwall, ON Mr. Gib McIntee Tel: 613 938-2521	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
St. Marys Leaside Lab Toronto, ON Mr. Stephen Parkes Tel: 416 423-2439	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓				
Stantec Consulting Limited Ottawa, ON Mr. Jeff Weng Tel: 613 738-0708	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Stantec Consulting Limited Kitchener, ON Mr. Kenton Power Tel: 519 579-4410	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Stantec Consulting Limited Markham, ON Ms. Brani Vujanovic Tel: 905 479-9345	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Steed and Evans Limited Heidelberg, ON Mr. Richard Marco Tel: 519 699-4646	✓	✓		✓		✓	✓							✓				
Taranis Contracting Group Thunder Bay, ON Mr. Dawn Molcan Tel: 807 475-5433	✓	✓				✓	✓							✓				

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TBT Engineering Limited Thunder Bay, ON Mr. Tim Fummerton Tel: 807 624-5162	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Teranorth Construction & Engineering Ltd. Sudbury, ON Mr. James Bot Tel: 705 523-1540	✓	✓				✓	✓							✓	✓			
Terraprobe Inc. Brampton, ON Mr. Chris Elvidge Tel: 905 796-2650	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	✓
Terraprobe Inc. Barrie, ON Mr. Brian Jackson Tel: 705 739-8355	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Terraprobe Inc. Stoney Creek, ON Mr. Gerry Muckle Tel: 905 643-7560	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Terraprobe Inc. Sudbury, ON Mr. Dennis Paquette Tel: 705 670-0460	✓	✓				✓	✓							✓	✓	✓	✓	✓
Terraspec Engineering Inc. Peterborough, ON Mr. Shane Galloway Tel: 705 743-7880	✓	✓				✓	✓							✓	✓	✓	✓	✓
The Karson Group Carp, ON Mr. Cam MacDonald Tel: 613 831-0717	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓				
The Murray Group Moorefield, ON Mr. Brad Mitchell Tel: 519 323-4411	✓	✓				✓	✓							✓				
Thomas Cavanagh Construction Ltd. Ashton, ON Mr. Phil White Tel: 613 257-2918	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓		✓	✓
Thurber Engineering Limited Ottawa, ON Mr. Fred Griffiths Tel: 613 247-2121	✓	✓				✓	✓							✓	✓	✓	✓	✓
Thurber Engineering Limited Oakville, ON Mr. Weiss Mehdawi Tel: 905 829-8666	✓	✓				✓	✓							✓	✓	✓	✓	✓
Tri City Materials Petersburg, ON Mr. Ron Shantz Tel: 519 577-1000	✓	✓				✓	✓							✓				
True Grit Consulting Ltd. Thunder Bay, ON Mr. Adam Rose Tel: 807 626-5640	✓	✓				✓	✓							✓		✓	✓	✓
Tulloch Engineering Inc. Sault Ste. Marie, ON Mr. Daren Stadnisky Tel: 705 945-5090	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	✓
Vicdom Sand and Gravel Limited Uxbridge, ON Mr. Bruno Giordano Tel: 905 649-2193	✓	✓				✓	✓							✓				
Walker Aggregates Inc. Thorold, ON Mr. Tom Risi Tel: 905 227-4142	✓	✓		✓	✓	✓	✓				✓	✓		✓				

2013 Participants List

Ministry of Transportation
Aggregate and Soil
Proficiency Sample
Testing Program

For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Stephen Senior (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
Walker Aggregates Inc. Duntroon, ON Mr. Tom Risi Tel: 905 445-2300	✓	✓				✓	✓							✓				

Appendix B2: List of Participants

2013 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901 or Stephen Senior (416) 235-3734	ASTM D 1252/AASHTO T 304 - Uncompacted Void Content of Fine Aggregate	ASTM D 4219/AASHTO T 176 – Sand Equivalent Value of Fine	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
AGS Associates Inc. Scarborough, ON Mr. Amjed Siddiqui Tel: 416 299-3655	✓	✓	✓	✓
AME -Materials Engineering Caledon, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓	✓	✓
AME -Materials Engineering Ottawa, ON Mr. Harrison Smith Tel: 613 726-3039	✓	✓	✓	✓
AMEC Earth & Environmental Limited Cambridge, ON Mr. Louis Maier Tel: 519 650-7115	✓	✓	✓	✓
AMEC Earth & Environmental Limited Hamilton, ON Mr. John Balinski Tel: 905 312-0700	✓	✓	✓	✓
AMEC Earth & Environmental Limited Scarborough, ON Mr. Mohammadsarif. Sufi Tel: 416 751-6565	✓	✓	✓	✓
AMEC Earth & Environmental Limited Tecumseh, ON Mr. Justin Palmer Tel: 519 735-2499	✓	✓	✓	✓
C. Villeneuve Construction – Mobile 1 Hearst, ON Mr. Charles Harris Tel: 705 372-1838	✓	✓	✓	✓
Cambium Inc. Peterborough, ON Mr. Wayne Rayfuse Tel: 705 742-7900	✓	✓	✓	✓
CCI Group Inc. Woodbridge, ON Mr. M. Sukhandan Tel: 905 856-5200	✓	✓	✓	✓
COCO Paving Inc. Belleville, ON Mr. Tom Woodcock Tel: 613 962-3461	✓	✓	✓	✓
COCO Paving Inc. Windsor, ON Mr. Ishaq Syed Tel: 519 948-7133	✓	✓	✓	✓
COCO Paving Inc. Ottawa, ON Mr. Brad Gooderham Tel: 613 907-7283	✓	✓	✓	✓
COCO Paving Inc. Toronto, ON Mr. Andrew Pahalan Tel: 416 347-3590	✓	✓	✓	✓
Construction Testing Asphalt Lab Cambridge, ON Mr. Peter Lung Tel: 519 622-7023	✓	✓	✓	✓
Cornwall Gravel Company Ltd. Cornwall, ON Ms. Billie-Gail Macfarlane Tel: 613 930-3530	✓	✓	✓	✓
Cox Construction Limited Guelph, ON Mr. Andrew Smith Tel: 519 824-6570	✓		✓	✓
Cruickshank Construction Elginburg, ON Mr. Tim Bilton Tel: 613 536-9112	✓	✓	✓	✓
Davroc Testing Laboratories Inc. Brampton, ON Mr. Sal Fasullo Tel: 905 792-7792	✓	✓	✓	✓
DBA Engineering Limited Kingston, ON Mr. Mark McClelland Tel: 613 389-1781	✓	✓	✓	✓

2013 Participants List

Ministry of Transportation

Superpave Aggregate Consensus Property Testing Program

For further information on this program, contact:

Mark Vasavithasan (416) 235-4901 or

Stephen Senior (416) 235-3734

	ASTM D 1252/AASHTO T 304 - Uncompacted Void Content of Fine Aggregate	ASTM D 4219/AASHTO T 176 – Sand Equivalent Value of Fine	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
DBA Engineering Limited Vaughan, ON Mr. Andy Burleigh Tel: 905 851-0090	✓	✓	✓	✓
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exp Services Inc. Brampton, ON Mr. Ammanuel Yousif Tel: 905 793-9800	✓	✓	✓	✓
exp Services Inc. Sudbury, ON Mr. Rob Ferguson Tel: 705 674-9681	✓	✓	✓	✓
Fermar Construction Limited Rexdale, ON Mr. Walter Di Francescantonio Tel: 416 629-2701	✓	✓	✓	✓
Fowler Construction Company Bracebridge, ON Mr. Ross Elliott Tel: 705 644-4037	✓	✓	✓	✓
Geo-Logic Inc. Peterborough, ON Mr. Matt Rawlings Tel: 705 749-3317	✓	✓	✓	✓
Golder Associates Limited Burnabay, BC Ms. Lily Hu Tel: 604 412-6899	✓	✓	✓	✓
Golder Associates Limited Cambridge, ON Ms. Jodi Noris Tel: 519 620-1222	✓	✓	✓	✓
Golder Associates Limited London, ON Mr. Chris Sewell Tel: 519 652-0099	✓	✓	✓	✓
Golder Associates Limited Sudbury, ON Ms. Sylvie LaPorte Tel: 705 524-6861	✓	✓	✓	✓
Golder Associates Limited Whitby, ON Mr. Jeremy Rose Tel: 905 723-2727	✓	✓	✓	✓
Graham Bros. Construction Limited Brampton, ON Mr. Greg Thompson Tel: 905 453-1200	✓	✓	✓	✓
Greenwood Aggregates Amaranth, ON Andrew Raymond Tel: 519 940-6844	✓	✓	✓	✓
Harold Sutherland Construction Limited Kemble, ON Mr. Roland Leigh Tel: 519 376-3506	✓	✓	✓	✓
Houle Chevrier Engineering Limited Carp, ON Mrs. Krystle Smith Tel: 613 836-1422	✓	✓	✓	✓
Interpaving Asphalt & Aggregate Supply Limited Sudbury, ON Ms. Ashley Edwards Tel: 705 694-6210	✓	✓	✓	✓
John D. Paterson & Associates North Bay, ON Mr. Stephen Walker Tel: 705 472-5331	✓	✓	✓	✓
K.J. Beamish Construction King City, ON Mr. Chad Henderson Tel: 905 833-4666	✓	✓	✓	✓
Lafarge Canada Inc. Hamilton, ON Mr. Mike Koch Tel: 905 979-3107	✓		✓	✓
Lafarge Canada Inc. Dundas, ON Mr. Chris Thomas Tel: 905 977-7363	✓		✓	✓

2013 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901 or Stephen Senior (416) 235-3734	ASTM D 1252/AASHTO T 304 - Uncompacted Void Content of Fine Aggregate	ASTM D 4219/AASHTO T 176 – Sand Equivalent Value of Fine	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
Landtek Limited Hamilton, ON Mr. Paul Anderson Tel: 905 383-3733	✓	✓	✓	✓
Lavis Contracting Co. Limited Clinton, ON Mr. Allan Gardner Tel: 519 482-3694	✓	✓	✓	✓
LVM Inc. Toronto, ON Mr. Dawit Amar Tel: 416 213-1060	✓	✓	✓	✓
McAsphalt Engineering Services Toronto, ON Mr. Michael Esenwa Tel: 416 282-8181	✓	✓	✓	✓
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Miller Northwest Limited – Mobile 942012 Dryden, ON Ms. Melodie Asselin Tel: 807 223-2844			✓	✓
Miller Paving Limited Markham, ON Ms. Carla Hariprashad Tel: 905 475-6660	✓	✓	✓	✓
Miller Paving Limited Port Colborne, ON Ms. Melissa Slipak Tel: 905 834-9227	✓	✓	✓	✓
Miller Paving Ltd. - Materials Research Lab Gormley, ON Ms. Amma Wakefield Tel: 905 726-9518	✓	✓	✓	✓
Miller Paving Ltd. - Mobile 1084 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓	✓	✓
Miller Paving Northern - Mobile 1254 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓	✓	✓
Miller Paving Northern - Mobile 60853 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓	✓	✓
Miller Paving Northern - Mobile 60889 North Bay, ON Mr. Herb Villneff Tel: 705 472-3312	✓	✓	✓	✓
Ministry of Transportation Downsview, ON Mr. Stephen Senior Tel: 416 235-3734	✓	✓	✓	✓
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Peto MacCallum Limited Hamilton, ON Mr. Amjad Khan Tel: 905 561-2231	✓	✓	✓	✓
Peto MacCallum Limited Kitchener, ON Mr. Gerry Mitchell Tel: 519 893-7500	✓	✓	✓	✓
Peto MacCallum Limited Toronto, ON Mr. Geoffrey Uwimana Tel: 416 785-5110	✓	✓	✓	✓
Pioneer Construction Inc. Sault Ste. Marie, ON Mrs. Shelley Geiling Tel: 705 541-2280	✓	✓	✓	✓
Pioneer Construction Inc. Thunder Bay, ON Mr. Tony Fazio Tel: 807 345-2338	✓	✓	✓	✓
Pioneer Construction Inc. Copper Cliff, ON Mr. David Pilkey Tel: 705 693-1363	✓	✓	✓	✓
R. W. Tomlinson Limited Ottawa , ON Mr. Paul Charbonneau Tel: 613 822-0543	✓	✓	✓	✓

2013 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901 or Stephen Senior (416) 235-3734	ASTM D 1252/AASHTO T 304 - Uncompacted Void Content of Fine Aggregate	ASTM D 4219/AASHTO T 176 – Sand Equivalent Value of Fine	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
SPL Consultants Limited Markham, ON Mr. Jordan Gadjanov Tel: 905 475-0065	✓	✓	✓	✓
St Lawrence Testing & Inspection Co. Ltd. Cornwall, ON Mr. Gib McIntee Tel: 613 938-2521	✓	✓	✓	✓
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Steed and Evans Ltd. Heidelberg, ON Mr. Richard Marco Tel: 519 699-4646	✓		✓	✓
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Terraprobe Inc. Brampton, ON Mr. Chris Elvidge Tel: 905 796-2650	✓	✓	✓	✓
The Karson Group Carp, ON Mr. Cameron MacDonald Tel: 613 831-0717	✓	✓	✓	✓
Thomas Cavanagh Construction Ltd. Ashton, ON Mr. Phil White Tel: 613 257-2918	✓	✓	✓	✓

Appendix C: Multi-Laboratory Precision

Test 1	2010		2011		2012		2013		MTO LS-601
WP 75 μm	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	
Mean	0.56	0.55	0.97	1.11	2.39	2.26	1.22	1.22	< 2.0
1S	0.19	0.19	0.25	0.29	0.31	0.32	0.28	0.25	0.19
D2S	0.55	0.55	0.71	0.83	0.86	0.90	0.79	0.72	0.53
n/Outliers	221/6		210/11		199/18		201/21		

Test 2	2010		2011		2012		2013		ASTM C136[A]
P 19.0 mm	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	
Mean	95.8	96.0	96.5	96.2	95.0	93.7	95.8	95.8	100 - 95
1S	0.9	0.7	0.7	0.8	1.0	1.1	0.8	0.8	0.35
D2S	2.4	1.9	1.9	2.1	2.8	3.1	2.4	2.4	1.0
n/Outliers	227/0		215/7		215/2		213/10		

Test 3	2010		2011		2012		2013		ASTM C136[A]
P 16.0 mm	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	
Mean	89.3	89.8	86.4	85.3	90.2	87.6	90.0	89.9	95 - 85
1S	1.4	1.0	1.1	1.6	1.6	1.6	1.1	1.2	1.37
D2S	4.0	2.9	3.0	4.6	4.6	4.6	3.1	3.5	3.9
n/Outliers	224/3		208/14		211/5		207/15		

Test 4	2010		2011		2012		2013		ASTM C136[A]
P 13.2 mm	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	
Mean	82.8	83.6	76.2	74.4	85.4	82.0	83.7	83.6	85 - 80
1S	1.7	1.3	1.4	2.1	1.9	1.8	1.5	1.5	1.92
D2S	4.9	3.6	3.8	5.9	5.5	5.2	4.3	4.3	5.4
n/Outliers	226/1		214/8		209/8		209/14		

Test 5	2010		2011		2012		2013		ASTM C136[A]
P 9.5 mm	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	
Mean	71.5	72.4	62.0	59.6	75.8	71.5	72.1	71.8	80 – 60
1S	1.8	1.5	1.7	2.3	2.3	2.2	1.6	1.7	2.82
D2S	5.2	4.3	4.8	6.4	6.4	6.4	4.5	4.8	8.0
n/Outliers	226/1		215/7		210/7		201/22		

Test 6	2010		2011		2012		2013		ASTM C136[A]
P 4.75 mm	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	
Mean	53.4	54.2	46.5	44.0	58.1	53.8	54.8	54.2	60 – 20
1S	1.7	1.5	1.8	2.0	2.3	2.2	1.5	1.7	1.97
D2S	4.7	4.1	5.1	5.7	6.6	6.2	4.3	4.9	5.6
n/Outliers	224/3		211/11		207/10		204/19		

Test 8	2010		2011		2012		2013		ASTM C131	
L. A	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	C of V	σ^*
Mean	22.4	22.1	24.2	23.8	22.6	21.9	22.2	22.1	10-45	22.1
1S	1.43	1.21	1.02	1.40	1.32	1.34	1.2	0.9	4.5%	1.0
D2S	4.05	3.42	2.89	3.96	3.73	3.81	3.3	2.5	12.7%	2.8
n/Outliers	13/0		12/1		11/0		9/1			

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 9	2010		2011		2012		2013		MTO LS-604
RD (O.D.)	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	
Mean	2.631	2.631	2.670	2.669	2.655	2.657	2.625	2.624	
1S	0.007	0.006	0.007	0.007	0.008	0.008	0.006	0.006	0.006
D2S	0.020	0.017	0.020	0.020	0.023	0.023	0.017	0.017	0.017
n/Outliers	105/6		96/11		102/3		98/6		

Test 10	2010		2011		2012		2013		MTO LS-604
ABS	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	
Mean	1.259	1.246	0.709	0.703	2.094	2.063	1.133	1.126	< 2%
1S	0.107	0.104	0.087	0.088	0.121	0.134	0.076	0.072	0.09
D2S	0.303	0.294	0.246	0.249	0.342	0.379	0.215	0.204	0.25
n/Outliers	109/2		101/6		102/3		101/3		

Test 11	2010		2011		2012		2013		ASTM C88	
$MgSO_4$	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	C of V	σ^*
Mean	5.9	5.5	15.1	14.9	26.1	25.3	3.7	3.5	9-20%	3.6
1S	1.9	1.6	2.9	2.2	5.4	5.3	1.8	1.9	25%	0.9
D2S	5.4	4.6	8.3	6.2	15.2	15.0	5.0	5.3	71%	2.5
n/Outliers	40/1		40/4		42/1		44/0			

Test 12	2010		2011		2012		2013		MTO LS-607
% Crush	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	
Mean	72.3	72.2	63.1	63.7	76.9	77.5	69.1	69.3	55% - 85%
1S	5.1	5.4	4.2	4.1	5.6	5.9	3.8	3.7	4.7
D2S	14.4	15.4	12.0	11.5	15.8	16.7	10.8	10.6	13.2
n/Outliers	206/21		202/20		201/15		208/14		

Test 13	2010		2011		2012		2013		MTO LS-608
% F & E	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	
Mean	7.1	6.7	2.4	2.5	3.7	3.6	6.9	6.7	2.0% - 9.5%
1S	2.6	2.4	1.2	1.3	1.8	1.9	2.5	2.4	2.3
D2S	7.3	6.7	3.3	3.5	5.1	5.3	7.2	6.7	6.4
n/Outliers	217/4		201/18		203/11		215/6		

Test 14	2010		2011		2012		2013		MTO LS-609
PN Conc.	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	
Mean	-	-	-	-	131.4	127.7	-	-	No Precision
1S	-	-	-	-	15.4	10.0	-	-	Statements for
D2S	-	-	-	-	43.3	24.7	-	-	this Test.
n/Outliers	28		28		28/8		35		

Test 16	2010		2011		2012		2013		MTO LS-618	
MDA, CA	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	C of V	σ
Mean	17.2	17.1	22.8	22.7	19.2	19.1	11.5	11.5	5-23%	11.5
1S	0.84	0.88	0.95	1.03	1.14	0.92	0.45	0.54	5.5%	0.63
D2S	2.37	2.49	2.70	2.91	3.23	2.59	1.27	1.52	15.4%	1.79
n/Outliers	69/5		70/7		72/5		76/4			

Test 17	2010		2011		2012		2013		MTO LS-614	
Freeze-thaw	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	C of V	σ
Mean	10.37	10.45	10.40	10.31	10.11	9.77	3.30	3.16	4-18%	3.23
1S	2.07	2.28	2.15	2.20	2.82	3.00	1.10	1.13	20.2%	0.65
D2S	5.85	6.46	6.09	6.21	8.00	8.51	3.10	3.19	57.1%	1.85
n/Outliers	53/4		55/2		58/1		60/2			

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 20	2010		2011		2012		2013		ASTM C136[A]
P 2.36 mm	3.10	4.10	3.11	4.11	3.12	4.12	3.13	4.13	
Mean	38.5	39.0	37.4	35.6	43.2	40.3	44.9	44.5	60 - 20
1S	2.1	2.3	1.9	1.9	2.5	2.3	1.9	1.8	1.41
D2S	6.1	6.5	5.4	5.4	7.0	6.4	5.5	5.0	4.0
n/Outliers	216/11		219/3		203/14		207/16		

Test 21	2010		2011		2012		2013		ASTM C136[A]
P 1.18 mm	3.10	4.10	3.11	4.11	3.12	4.12	3.13	4.13	
Mean	26.4	26.8	30.1	28.7	30.2	28.5	37.6	37.3	60 - 20
1S	2.1	2.3	1.9	1.8	2.2	2.1	1.9	1.7	1.41
D2S	6.0	6.4	5.3	5.1	6.2	5.9	5.5	4.9	4.0
n/Outliers	216/11		219/3		205/12		209/14		

Test 22	2010		2011		2012		2012		ASTM C136[A]
P 600 μm	3.10	4.10	3.11	4.11	3.12	4.12	3.13	4.13	
Mean	18.0	18.3	22.0	21.0	22.0	21.0	27.4	27.4	60 - 20
1S	1.7	1.7	1.5	1.4	1.6	1.7	1.5	1.5	1.41
D2S	4.7	4.8	4.3	3.9	4.5	4.9	4.3	4.3	4.0
n/Outliers	215/12		216/6		201/16		203/20		

Test 23	2010		2011		2012		2013		ASTM C136[A]
P 300 μm	3.10	4.10	3.11	4.11	3.12	4.12	3.13	4.13	
Mean	12.9	13.1	12.6	12.2	16.5	16.0	14.1	14.1	15 - 10
1S	1.1	1.2	0.8	0.8	1.2	1.2	0.84	0.85	0.73
D2S	3.2	3.4	2.3	2.3	3.5	3.4	2.4	2.4	2.1
n/Outliers	215/12		214/8		199/18		203/20		

Test 24	2010		2011		2012		2013		ASTM C136[A]
P 150 μm	3.10	4.10	3.11	4.11	3.12	4.12	3.13	4.13	
Mean	10.3	10.5	8.1	7.8	12.3	12.0	10.3	10.3	15 - 10
1S	0.8	0.9	0.5	0.5	0.8	0.8	0.6	0.6	0.73
D2S	2.4	2.5	1.4	1.4	2.3	2.3	1.8	1.8	2.1
n/Outliers	214/13		206/16		198/19		210/13		

Test 25	2010		2011		2012		2013		ASTM C136[A]
P 75 μm	3.10	4.10	3.11	4.11	3.12	4.12	3.13	4.13	
Mean	8.5	8.7	6.0	5.8	9.1	8.8	8.7	8.7	10 - 2
1S	0.7	0.6	0.4	0.4	0.6	0.6	0.5	0.5	0.65
D2S	1.9	1.8	1.0	1.0	1.7	1.7	1.5	1.5	1.8
n/Outliers	213/14		206/16		200/17		214/9		

Test 27	2010		2011		2012		2013		MTO LS-605
RD (O.D.)	3.10	4.10	3.11	4.11	3.12	4.12	3.13	4.13	
Mean	2.615	2.614	2.654	2.654	2.647	2.649	2.650	2.650	
1S	0.015	0.016	0.010	0.011	0.011	0.009	0.013	0.013	0.012
D2S	0.042	0.045	0.028	0.031	0.031	0.025	0.037	0.037	0.034
n/Outliers	95/10		99/5		95/10		99/4		

Test 28	2010		2011		2012		2013		MTO LS-605
ABS	3.10	4.10	3.11	4.11	3.12	4.12	3.13	4.13	
Mean	1.499	1.516	0.700	0.684	1.171	1.148	1.351	1.329	< 2.0%
1S	0.19	0.20	0.12	0.12	0.15	0.16	0.16	0.12	0.16
D2S	0.53	0.57	0.34	0.34	0.44	0.46	0.44	0.34	0.45
n/Outliers	98/7		94/10		96/9		93/10		

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 30	2010		2011		2012		2013		MTO LS-621
% ACP	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	
Mean	31.2	31.2	36.4	37.0	47.1	47.6	54.4	54.8	25% - 45%
1S	7.0	7.2	3.5	3.3	5.4	5.2	2.9	3.0	3.8
D2S	19.7	20.4	9.8	9.2	15.2	14.8	8.1	8.4	10.8
n/Outliers	223/4		214/7		205/11		202/20		

Test 31	2010		2011		2012		2013		MTO LS-623
MWD	3.10	4.10	3.11	4.11	1.12	2.12	1.13	2.13	
Mean	2.323	2.322	2.315	2.318	2.416	2.421	2.422	2.425	
1S	0.027	0.029	0.033	0.038	0.032	0.032	0.024	0.024	0.030
D2S	0.076	0.082	0.093	0.107	0.090	0.090	0.070	0.070	0.085
n/Outliers	149/12		150/10		133/14		141/14		

Test 32	2010		2011		2012		2013		MTO LS-623
MDD	3.10	4.10	3.11	4.11	1.12	2.12	1.13	2.13	
Mean	2.152	2.154	2.147	2.154	2.257	2.264	2.265	2.267	
1S	0.030	0.029	0.032	0.033	0.035	0.034	0.025	0.027	0.033
D2S	0.085	0.082	0.090	0.093	0.099	0.096	0.071	0.076	0.093
n/Outliers	152/9		146/14		140/7		144/11		

Test 33	2010		2011		2012		2013		MTO LS-623
OMC	3.10	4.10	3.11	4.11	1.12	2.12	1.13	2.13	
Mean	7.95	7.96	7.99	7.94	7.13	7.07	7.05	7.02	
1S	0.32	0.29	0.30	0.28	0.33	0.33	0.26	0.26	0.38
D2S	0.89	0.81	0.85	0.79	0.93	0.92	0.74	0.74	1.07
n/Outliers	144/17		141/19		144/3		146/9		

Test 34	2010		2011		2012		2012		MTO LS-619	
MDA, FA3	3.10	4.10	3.11	4.11	3.12	4.12	3.13	4.13	C of V	σ
Mean	15.5	15.5	10.7	10.7	17.6	17.7	15.6	15.7	7-18%	15.7
1S	1.1	1.1	0.8	0.9	1.1	1.1	1.2	1.2	7.7%	1.2
D2S	3.1	3.2	2.1	2.6	3.0	3.0	3.4	3.4	21.8%	3.4
n/Outliers	69/5		74/3		71/6		79/1			

Test 40	2010		2011		2012		2013		MTO LS-702
P 2.0 mm	5.10	6.10	5.11	6.11	5.12	6.12	5.13	6.13	
Mean	100	100	99.0	98.9	100	100	99.6	99.8	No MTO
1S			0.6	0.7			0.3	0.2	precision
D2S			1.7	1.8			0.9	0.5	statements for
n/Outliers	74/0		71/5		76/0		90/0		this test

Test 41	2010		2011		2012		2013		MTO LS-702
P 425 µm	5.10	6.10	5.11	6.11	5.12	6.12	5.13	6.13	
Mean	96.4	96.5	96.2	95.9	99.8	99.8	96.7	97.0	No MTO
1S	0.4	0.4	0.7	0.9	0.2	0.2	0.7	0.5	precision
D2S	1.1	1.0	2.1	2.7	0.5	0.5	1.9	1.5	statements for
n/Outliers	67/7		67/9		71/5		86/4		this test

Test 42	2010		2011		2012		2013		MTO LS-702
P 75 µm	5.10	6.10	5.11	6.11	5.12	6.12	5.13	6.13	
Mean	88.6	88.7	90.7	90.4	99.1	99.1	91.3	91.7	No MTO
1S	0.5	0.3	1.1	1.2	0.3	0.3	1.0	0.9	precision
D2S	1.3	1.0	3.1	3.5	1.0	1.0	2.9	2.6	statements for
n/Outliers	63/11		69/7		71/5		88/2		this test

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 43	2010		2011		2012		2013		MTO LS-702
P 20 µm	5.10	6.10	5.11	6.11	5.12	6.12	5.13	6.13	
Mean	70.6	70.7	78.0	77.6	80.6	80.6	79.3	79.3	No MTO
1S	4.4	4.2	4.2	4.0	4.2	4.2	3.4	3.1	precision
D2S	12.5	12.0	12.0	11.4	12.0	12.0	9.5	8.7	statements for
n/Outliers	73/1		74/2		74/2		85/5		this test

Test 44	2010		2011		2012		2013		MTO LS-702
P 5 µm	5.10	6.10	5.11	6.11	5.12	6.12	5.13	6.13	
Mean	44.8	44.6	58.2	58.3	43.7	43.9	59.4	58.9	No MTO
1S	3.0	3.3	4.3	3.9	2.7	2.6	3.4	3.1	precision
D2S	8.5	9.4	12.1	11.0	7.7	7.2	9.6	8.7	statements for
n/Outliers	69/5		73/3		71/5		84/6		this test

Test 45	2010		2011		2012		2013		MTO LS-702
P 2 µm	5.10	6.10	5.11	6.11	5.12	6.12	5.13	6.13	
Mean	30.9	30.5	43.6	43.7	28.6	28.8	43.9	43.9	No MTO
1S	2.7	3.4	3.0	3.2	2.3	2.3	2.4	2.8	precision
D2S	7.8	9.6	8.5	9.1	6.6	6.6	6.8	8.0	statements for
n/Outliers	68/6		72/4		72/4		81/9		this test

Test 46	2010		2011		2012		2013		ASTM D4318
L. L	5.10	6.10	5.11	6.11	5.12	6.12	5.13	6.13	
Mean	27.0	27.2	36.6	36.7	32.2	32.2	37.1	37.1	33.3
1S	1.3	1.4	1.3	1.6	1.2	1.2	1.3	1.4	0.8
D2S	3.7	4.0	3.7	4.4	3.3	3.3	3.8	3.9	2
n/Outliers	84/6		88/6		89/6		103/5		

Test 47	2010		2011		2012		2013		ASTM D4318
P. L	5.10	6.10	5.11	6.11	5.12	6.12	5.13	6.13	
Mean	15.3	15.2	18.6	18.7	18.9	18.9	18.8	18.7	19.9
1S	1.0	1.1	1.4	1.3	1.1	1.1	1.3	1.1	1.3
D2S	2.8	3.0	3.9	3.7	3.1	3.1	3.6	3.2	4
n/Outliers	86/4		92/2		86/9		104/4		

Test 48	2010		2011		2012		2013		ASTM D4318
P. I	5.10	6.10	5.11	6.11	5.12	6.12	5.13	6.13	
Mean	11.8	11.9	17.9	17.9	13.3	13.4	18.4	18.3	13.4
1S	1.4	1.5	1.6	1.6	1.7	1.7	1.6	1.4	1.6
D2S	4.0	4.4	4.6	4.6	4.8	4.8	4.5	4.1	4
n/Outliers	86/4		89/5		93/2		101/7		

Test 49	2010		2011		2012		2013		AASHTO T 100
SG of Soils	5.10	6.10	5.11	6.11	5.12	6.12	5.13	6.13	
Mean	2.729	2.729	2.734	2.734	2.721	2.718	2.733	2.734	
1S	0.026	0.029	0.032	0.034	0.023	0.023	0.024	0.025	0.04
D2S	0.074	0.082	0.090	0.096	0.065	0.065	0.068	0.071	0.11
n/Outliers	58/7		63/5		60/10		74/9		

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 95	2010		2011		2012		2013		ASTM C1252
UC Void	3.10	4.10	3.11	4.11	3.12	4.12	3.13	4.13	
Mean	43.02	43.00	40.87	40.87	44.0	44.1	42.2	42.3	ASTM C1252[A]
1S	0.77	0.67	0.71	0.54	0.66	0.63	0.64	0.65	0.33%
D2S	2.18	1.90	2.00	1.53	1.86	1.78	1.80	1.85	0.93%
n/Outliers	58/8		59/7		66/5		71/1		

Test 96	2010		2011		2012		2013		ASTM D2419
SE Value	3.10	4.10	3.11	4.11	3.12	4.12	3.13	4.13	
Mean	35.8	35.7	36.8	35.8	32.5	32.0	42.8	42.7	< 80
1S	7.60	7.50	3.81	4.29	3.62	3.67	8.0	7.7	8.0
D2S	21.43	21.36	10.79	12.15	10.24	10.38	22.7	21.8	22.6
n/Outliers	60/2		56/7		65/2		68/0		

Test 97	2010		2011		2012		2013		ASTM D5821
% Fractured	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	
Mean	74.6	75.1	63.6	64.2	78.5	78.8	71.4	71.4	76.0%
1S	3.8	3.8	4.9	5.4	5.4	6.4	4.6	4.3	5.2%
D2S	10.8	10.7	13.8	15.3	15.4	18.1	12.9	12.2	14.7%
n/Outliers	67/3		69/2		70/2		72/2		

Test 99	2010		2011		2012		2013		ASTM D4791
% F & E	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	
Mean	1.57	1.37	0.24	0.31	0.66	0.55	1.43	1.43	19.0 -12.5 mm
1S	0.83	0.71	0.19	0.26	0.46	0.32	0.80	0.78	88.5%
D2S	2.35	2.00	0.53	0.73	1.30	0.89	2.27	2.21	250.3%
n/Outliers	69/3		65/7		66/6		72/2		

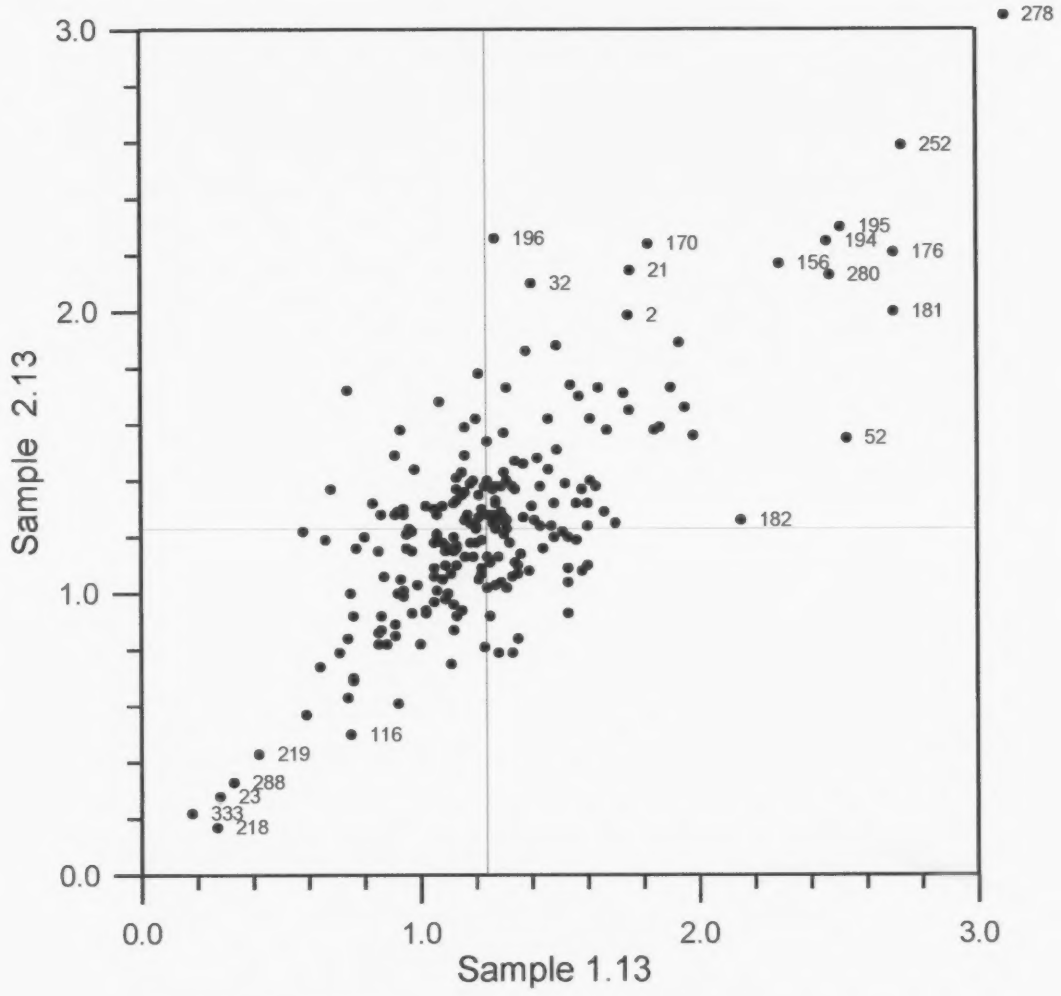
Test 123	2010		2011		2012		2013		ASTM C1260
Mortar Bar	1.10	2.10	1.11	2.11	1.12	2.12	1.13	2.13	
Mean	0.191	0.373	Not		Not		Not		Expansion >0.1%
1S	0.028	0.045	Conducted		Conducted		Conducted		15.2%
D2S	0.079	0.127							
n/Outliers	19/1								43%

A – AMRL reports percent passing inch series equivalent sieves.

σ^{*} - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Appendix D1: Scatter Diagrams

2013 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



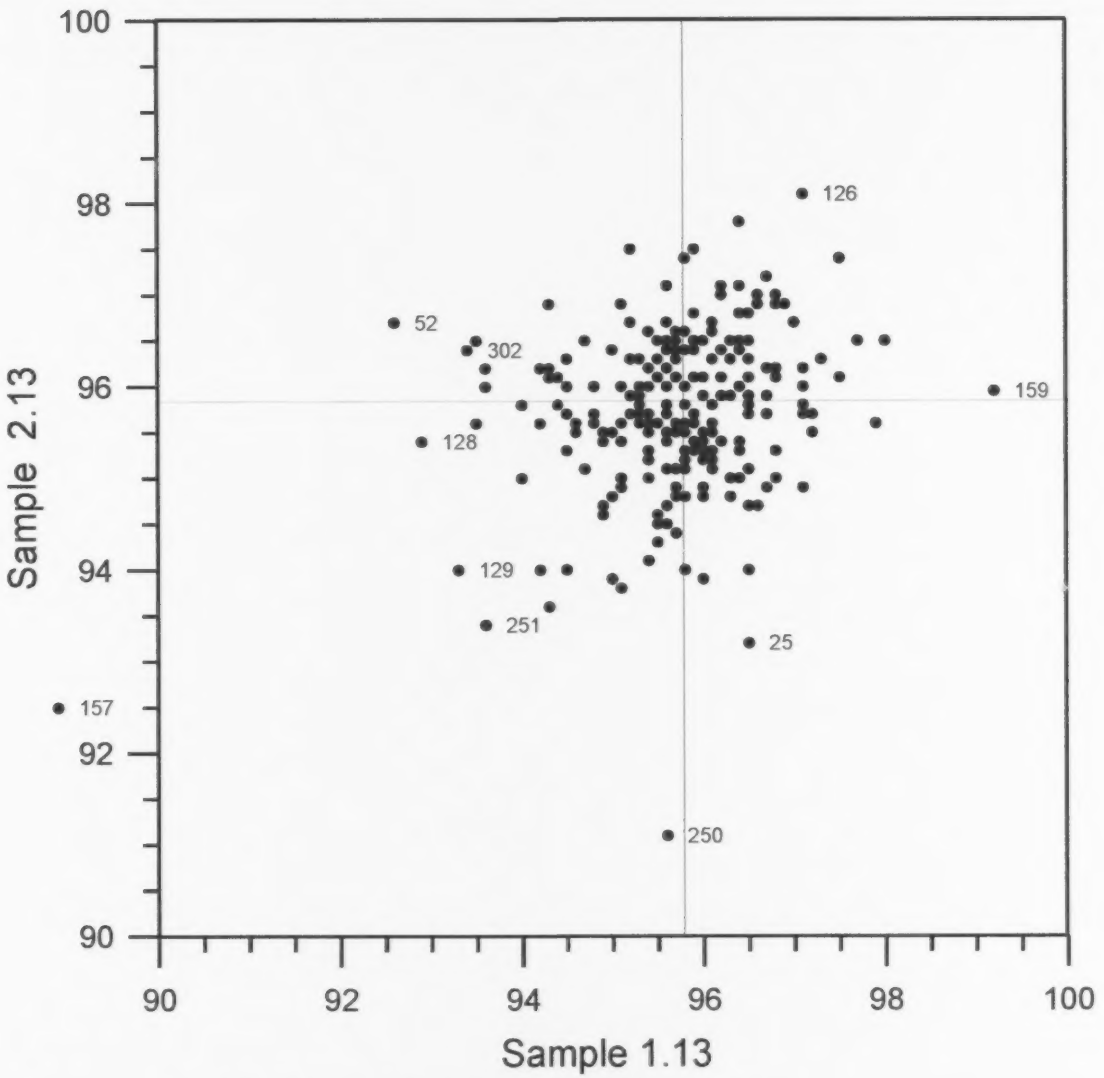
Test 1: Wash Pass 75 um

	Mat 1	Mat 2
Mean	1.216	1.223
Median	1.280	1.230
Std Dev	0.280	0.255

n = 201

Labs Eliminated: 2; 21; 23; 32; 52; 116; 156; 170; 176; 181; 182; 194; 195; 196; 218; 219; 252; 278; 280; 288; 333

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



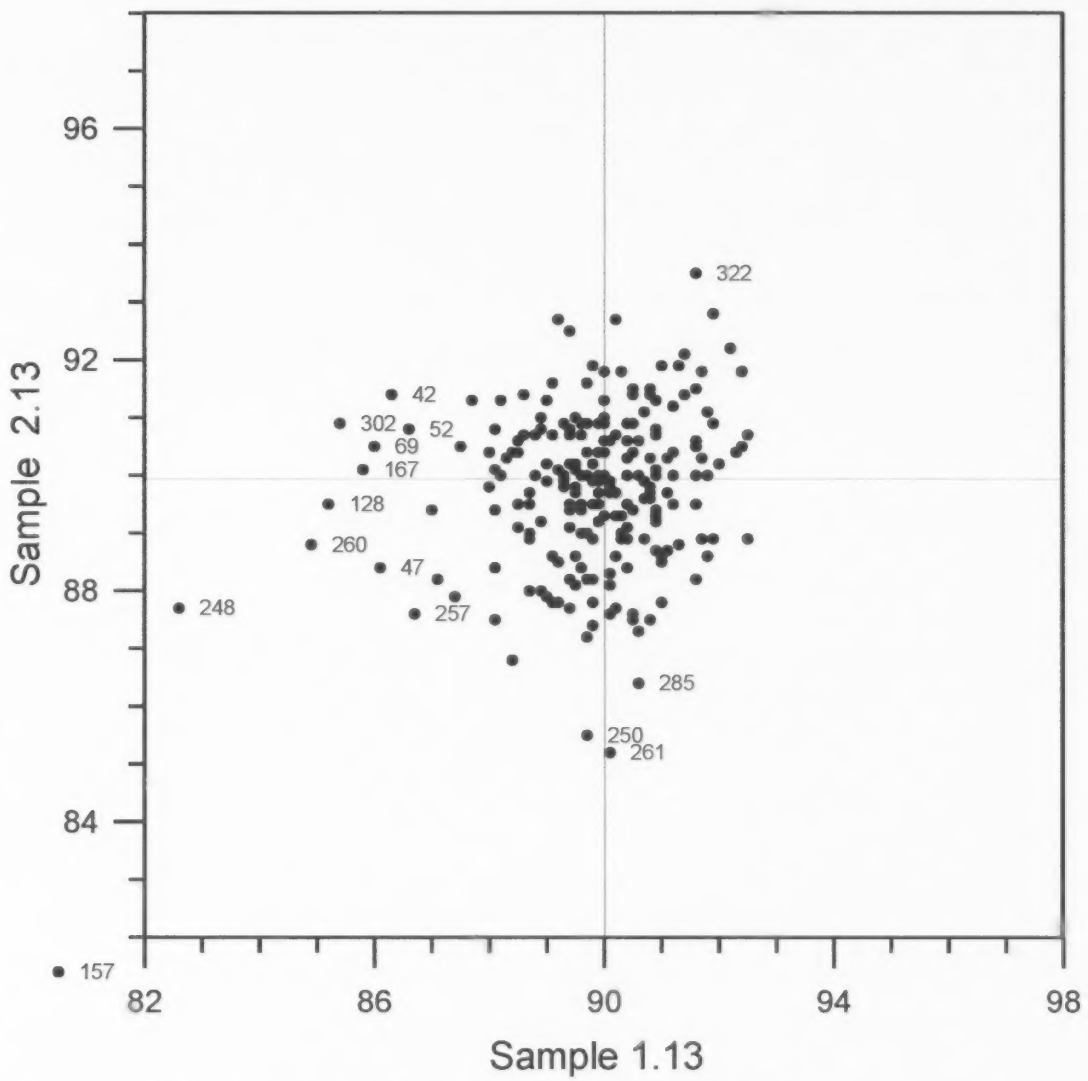
Test 2: Percent Passing the 19.0 mm Sieve

	Mat 1	Mat 2
Mean	95.759	95.779
Median	95.750	95.700
Std Dev	0.835	0.790

n = 213

Labs Eliminated: 25; 52; 126; 128; 129; 157; 159; 250; 251; 302

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



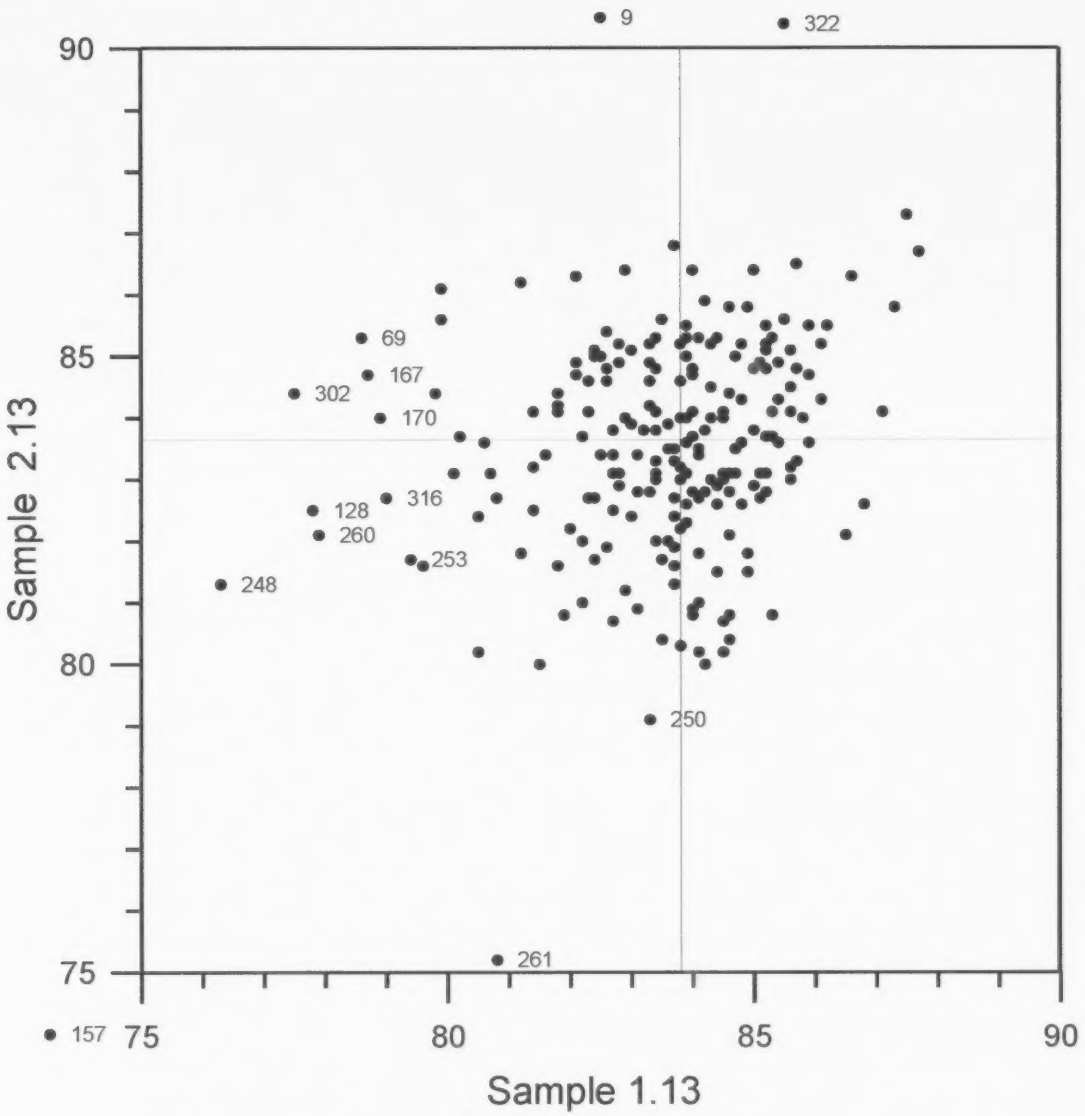
Test 3: Percent Passing the 16.0 mm Sieve

	Mat 1	Mat 2
Mean	90.016	89.861
Median	89.750	89.800
Std Dev	1.111	1.223

n = 207

Labs Eliminated: 42; 47; 52; 69; 128; 157; 167; 248; 250; 257; 260; 261; 285; 302; 322

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



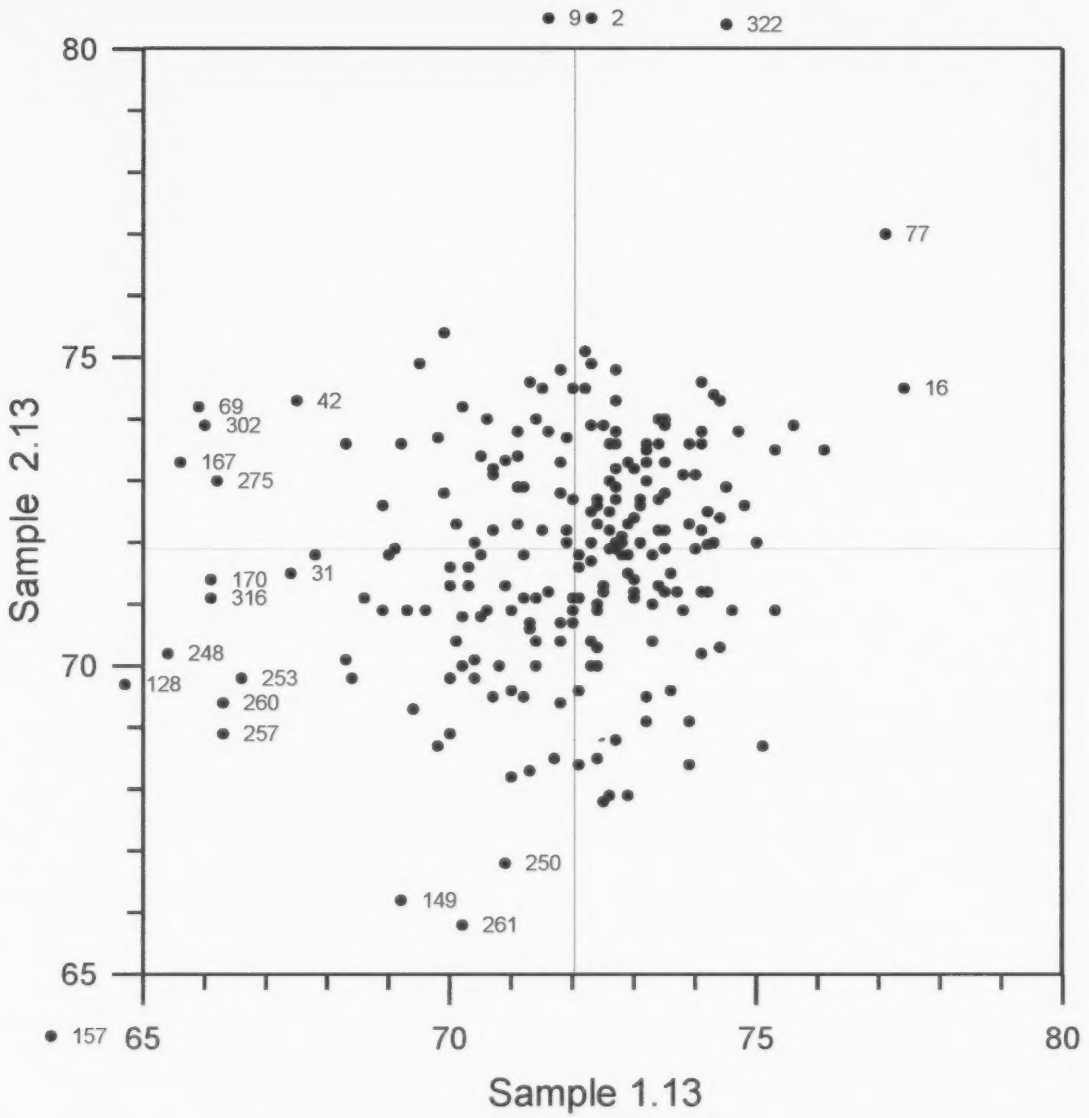
Test 4: Percent Passing the 13.20 mm Sieve

	Mat 1	Mat 2
Mean	83.755	83.579
Median	83.650	83.650
Std Dev	1.518	1.546

n = 209

Labs Eliminated: 9; 69; 128; 157; 167; 170; 248; 250; 253; 260; 261; 302; 316; 322

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



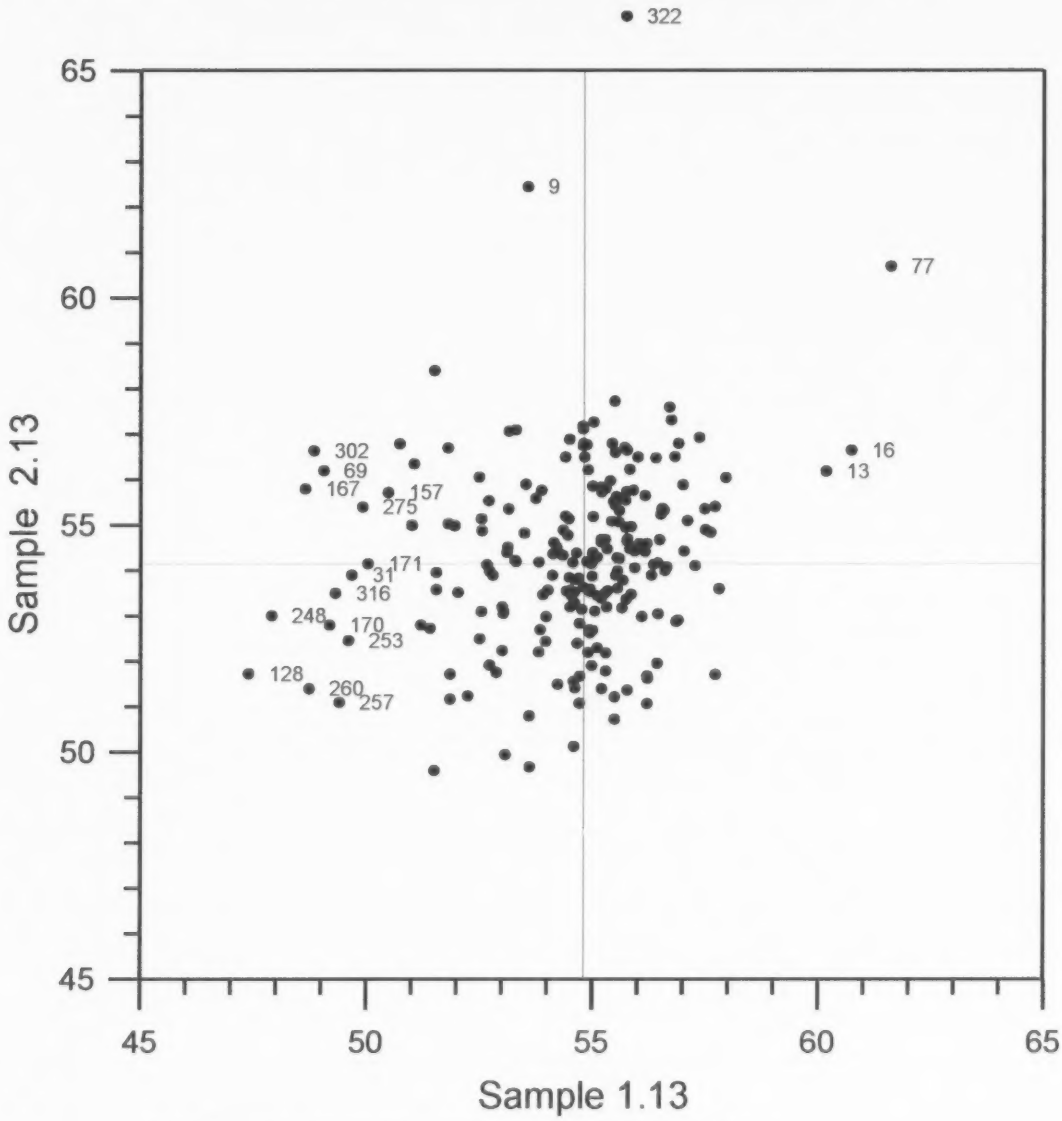
Test 5: Percent Passing the 9.5 mm Sieve

	Mat 1	Mat 2
Mean	72.155	71.848
Median	71.950	71.600
Std Dev	1.596	1.691

n = 201

Labs Eliminated: 2; 9; 16; 31; 42; 69; 77; 128; 149; 157; 167; 170; 248; 250 253; 257; 260; 261; 275; 302; 316; 322

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



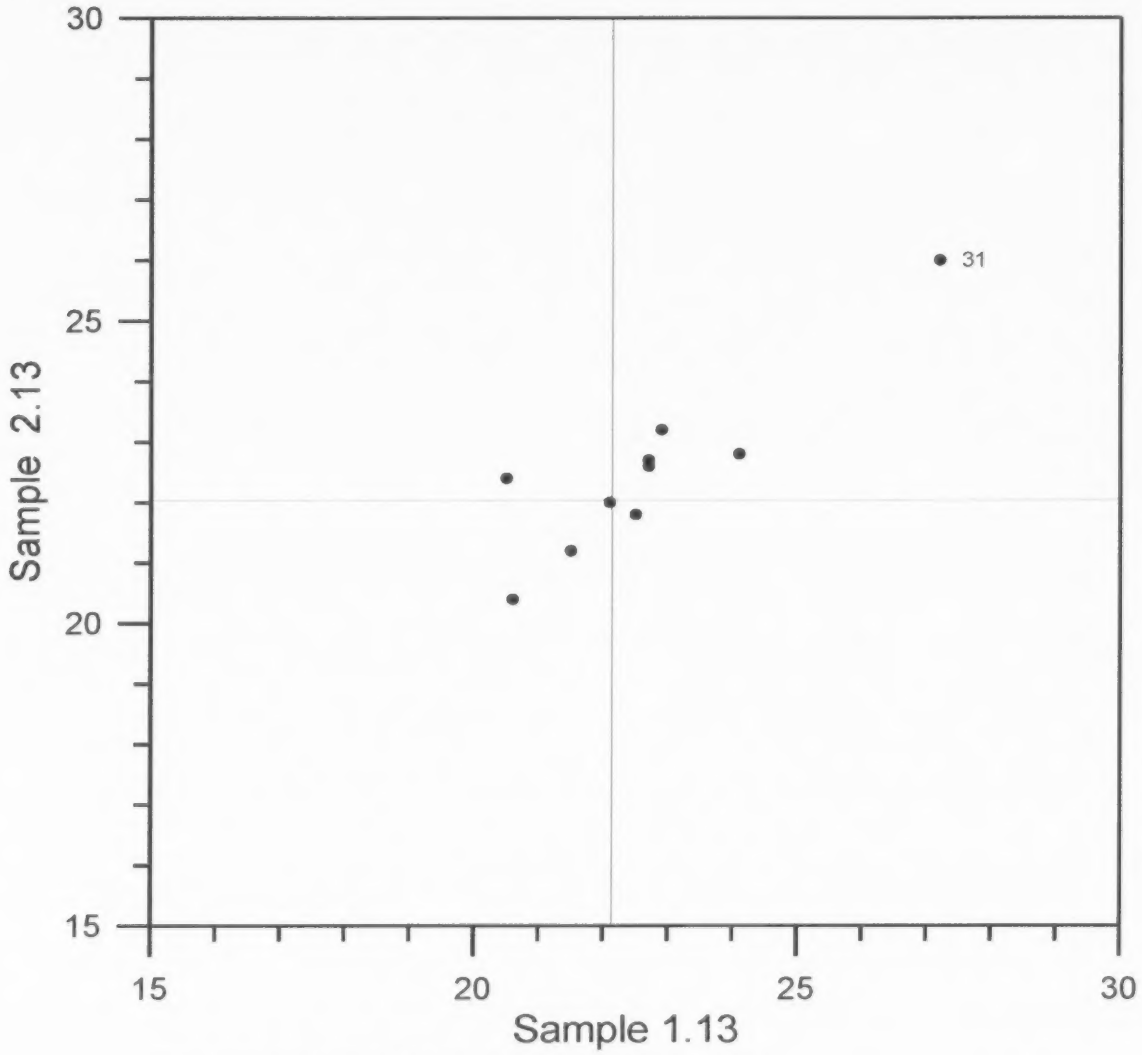
Test 6: Percent Passing the 4.75 mm Sieve

	Mat 1	Mat 2
Mean	54.793	54.217
Median	54.340	54.000
Std Dev	1.512	1.736

n = 204

Labs Eliminated: 9; 13; 16; 31; 69; 77; 128; 157; 167; 170; 171; 248; 253; 257; 260; 275; 302; 316; 322

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



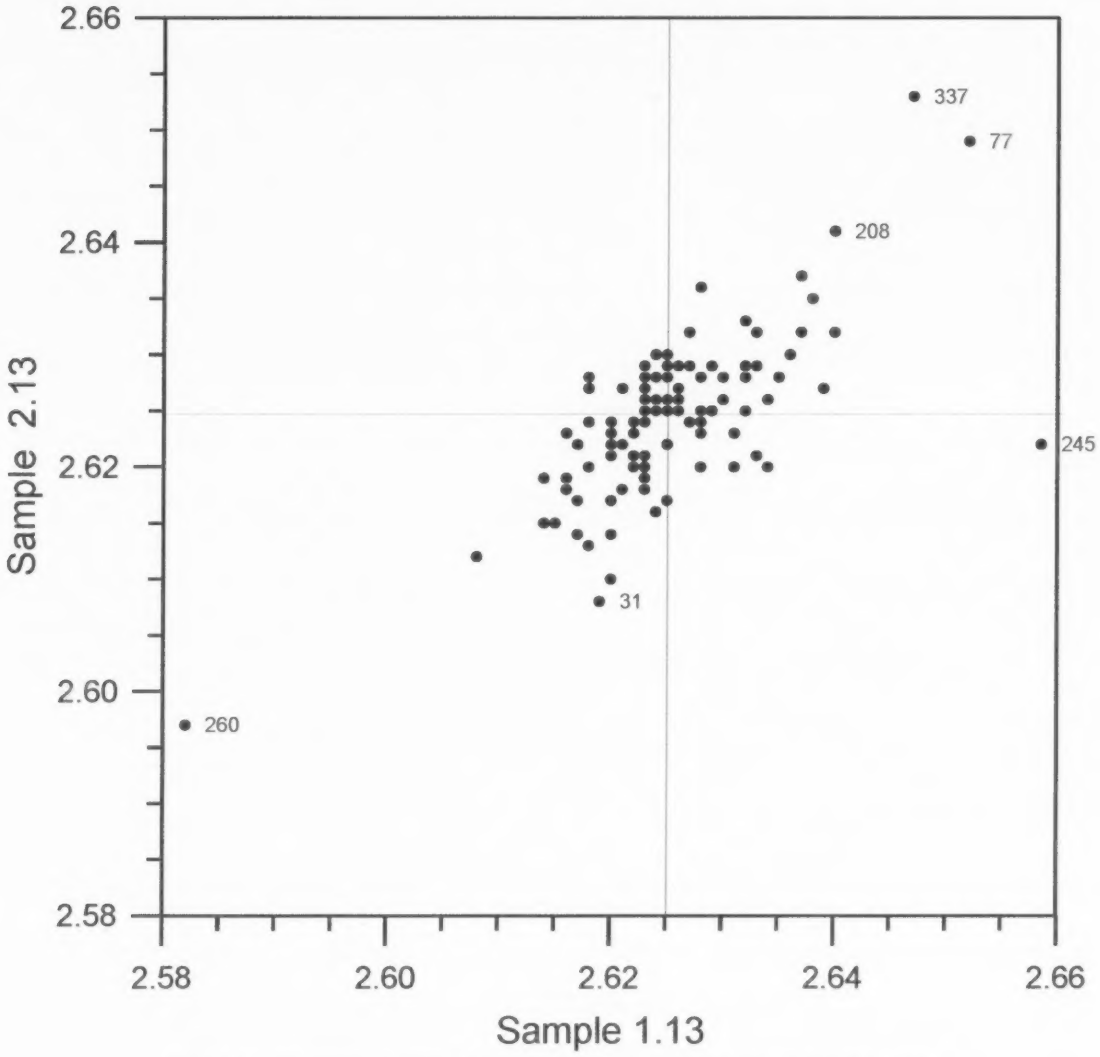
Test 8: Los Angeles Abrasion Loss, %

	Mat 1	Mat 2
Mean	22.178	22.122
Median	22.300	21.800
Std Dev	1.153	0.880

n = 9

Lab Eliminated: 31

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



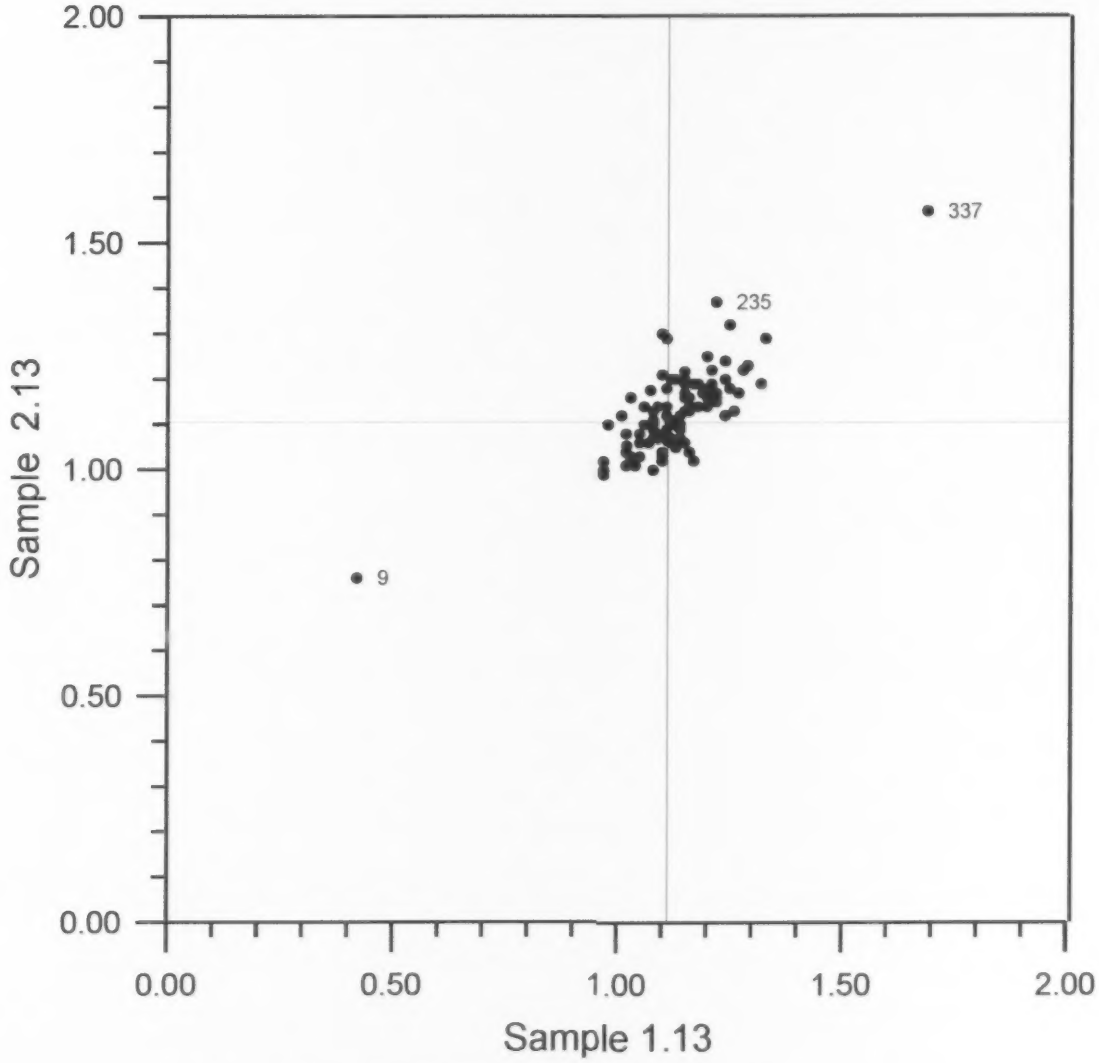
Test 9: Relative Density of Coarse Aggregate (O. D)

	Mat 1	Mat 2
Mean	2.625	2.624
Median	2.624	2.624
Std Dev	0.006	0.006

n = 98

Labs Eliminated: 31; 77; 208; 245; 260; 337

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



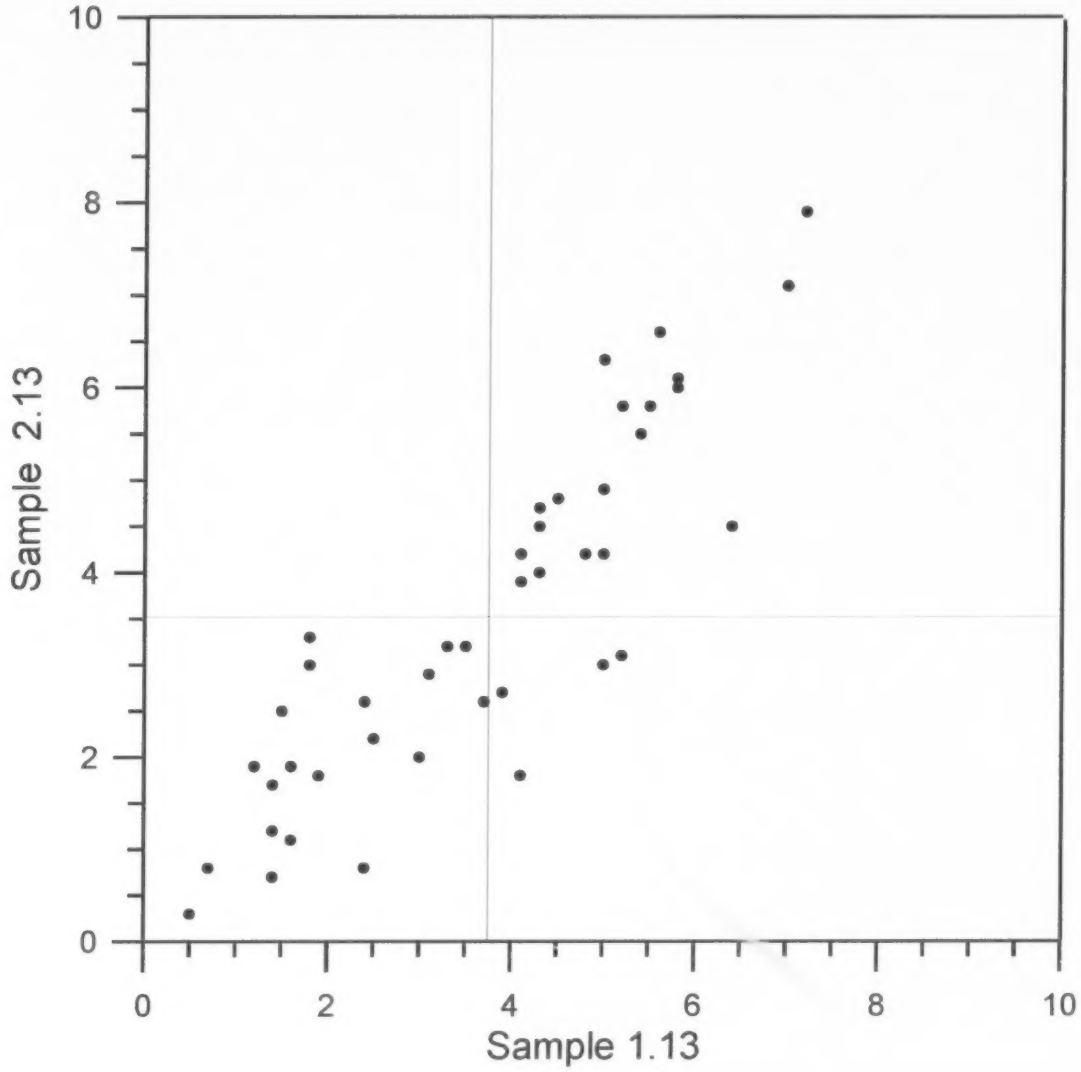
Test 10: Absorption of Coarse Aggregate

	Mat 1	Mat 2
Mean	1.133	1.126
Median	1.150	1.155
Std Dev	0.076	0.072

n = 101

Labs Eliminated: 9; 235; 337

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



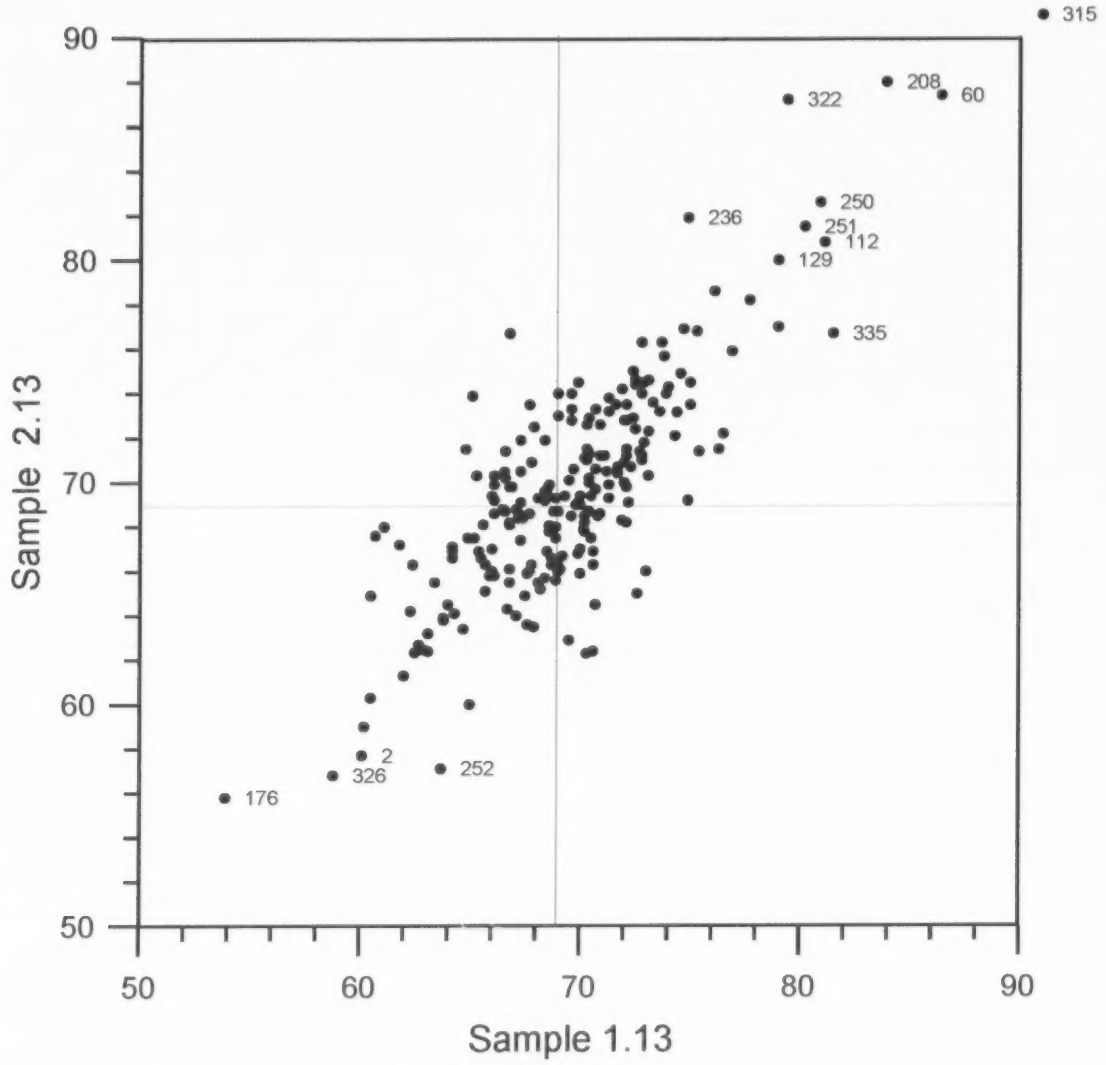
Test 11: MgSO4 Soundness of Coarse Aggregate, % Loss

	Mat 1	Mat 2
Mean	3.693	3.541
Median	3.850	4.100
Std Dev	1.775	1.890

n = 44

Labs Eliminated: None

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



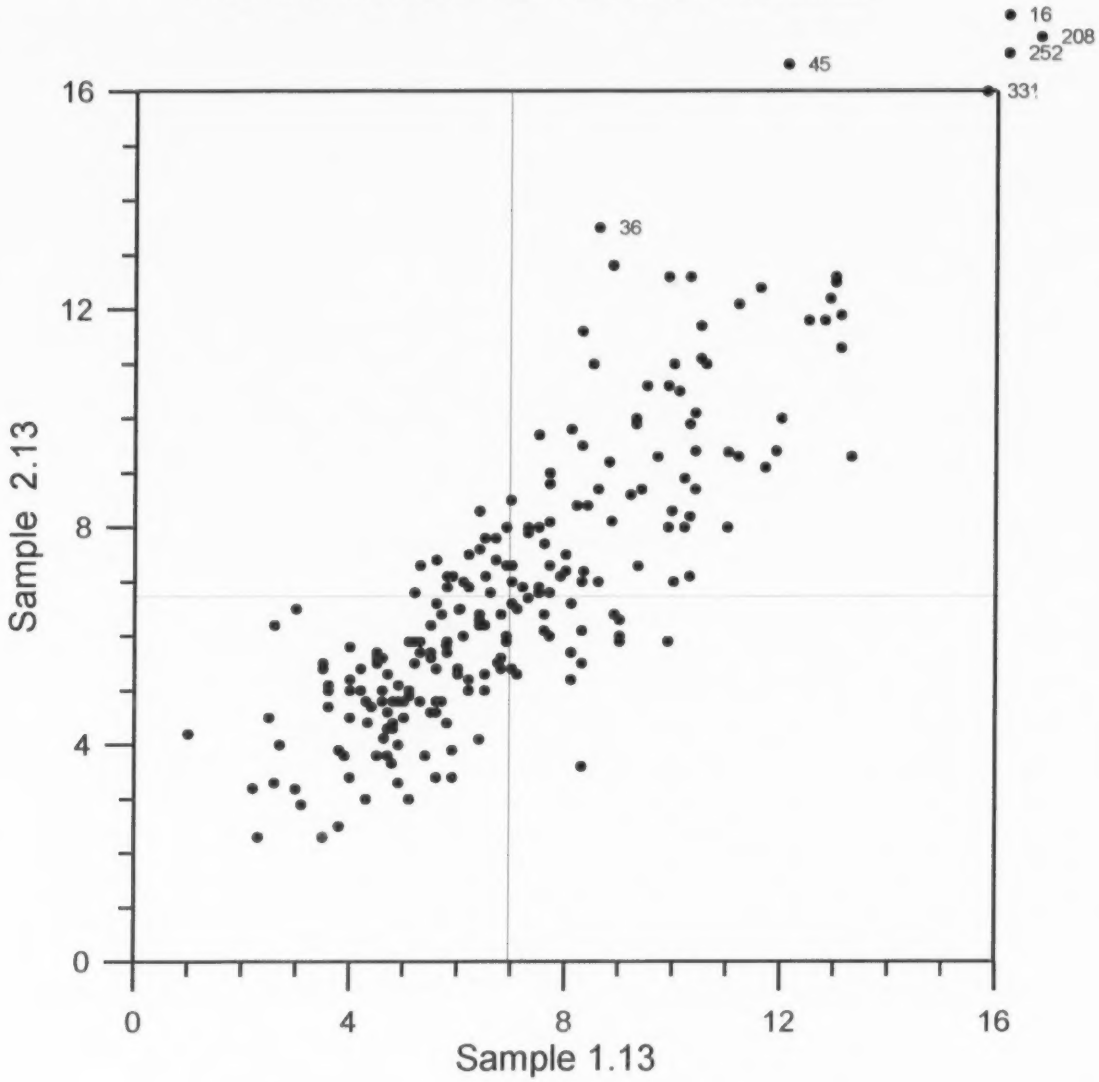
Test 12: Percent Crushed Particles

	Mat 1	Mat 2
Mean	69.139	69.314
Median	69.600	68.800
Std Dev	3.808	3.749

n = 208

Labs Eliminated: 2; 60; 112; 129; 176; 208; 236; 250; 251; 252; 315; 322; 326; 335

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



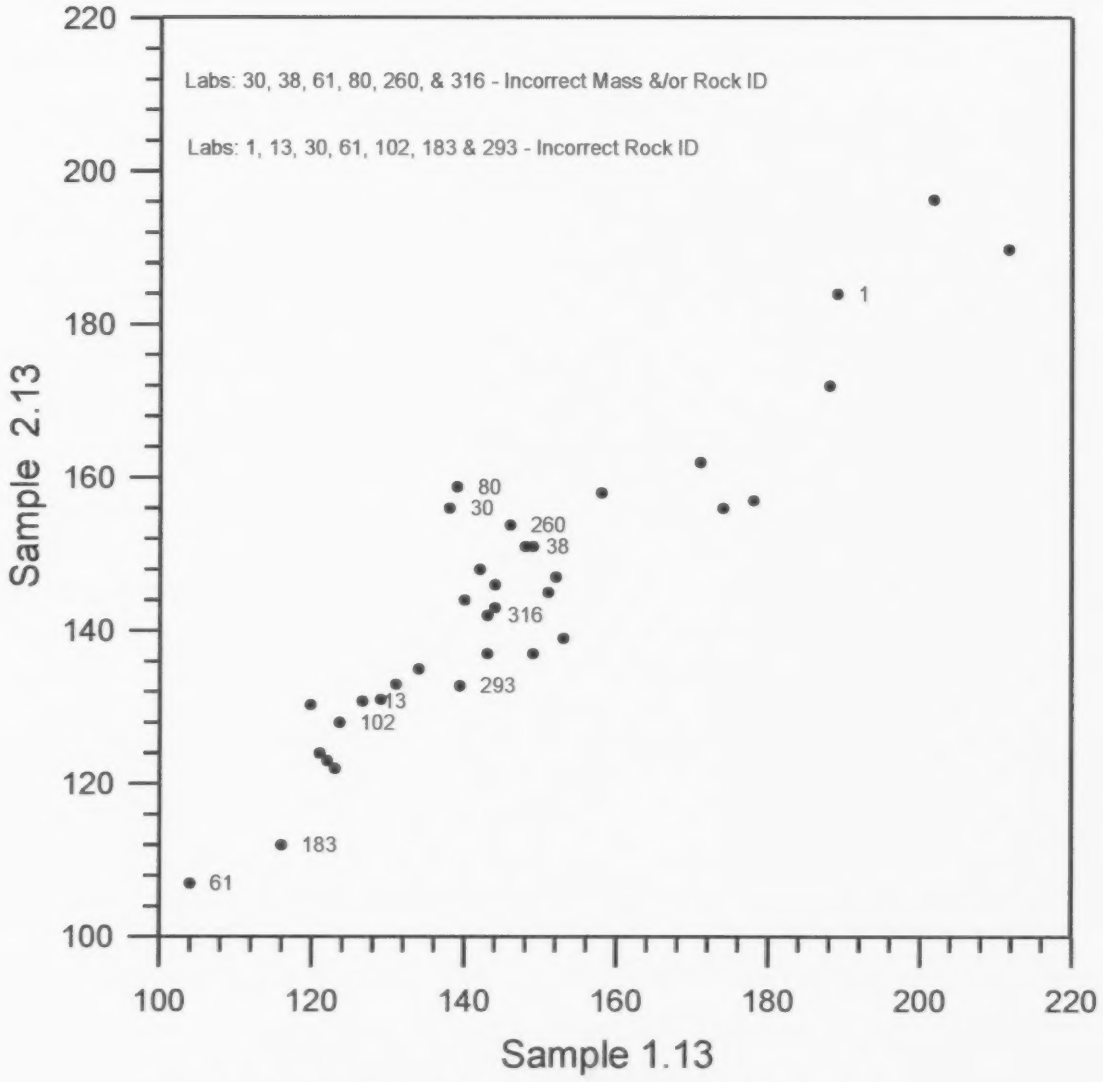
Test 13: Percent Flat and Elongated Particles

	Mat 1	Mat 2
Mean	6.960	6.720
Median	7.150	7.555
Std Dev	2.537	2.383

n = 215

Labs Eliminated: 16; 36; 45; 208; 252; 331

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

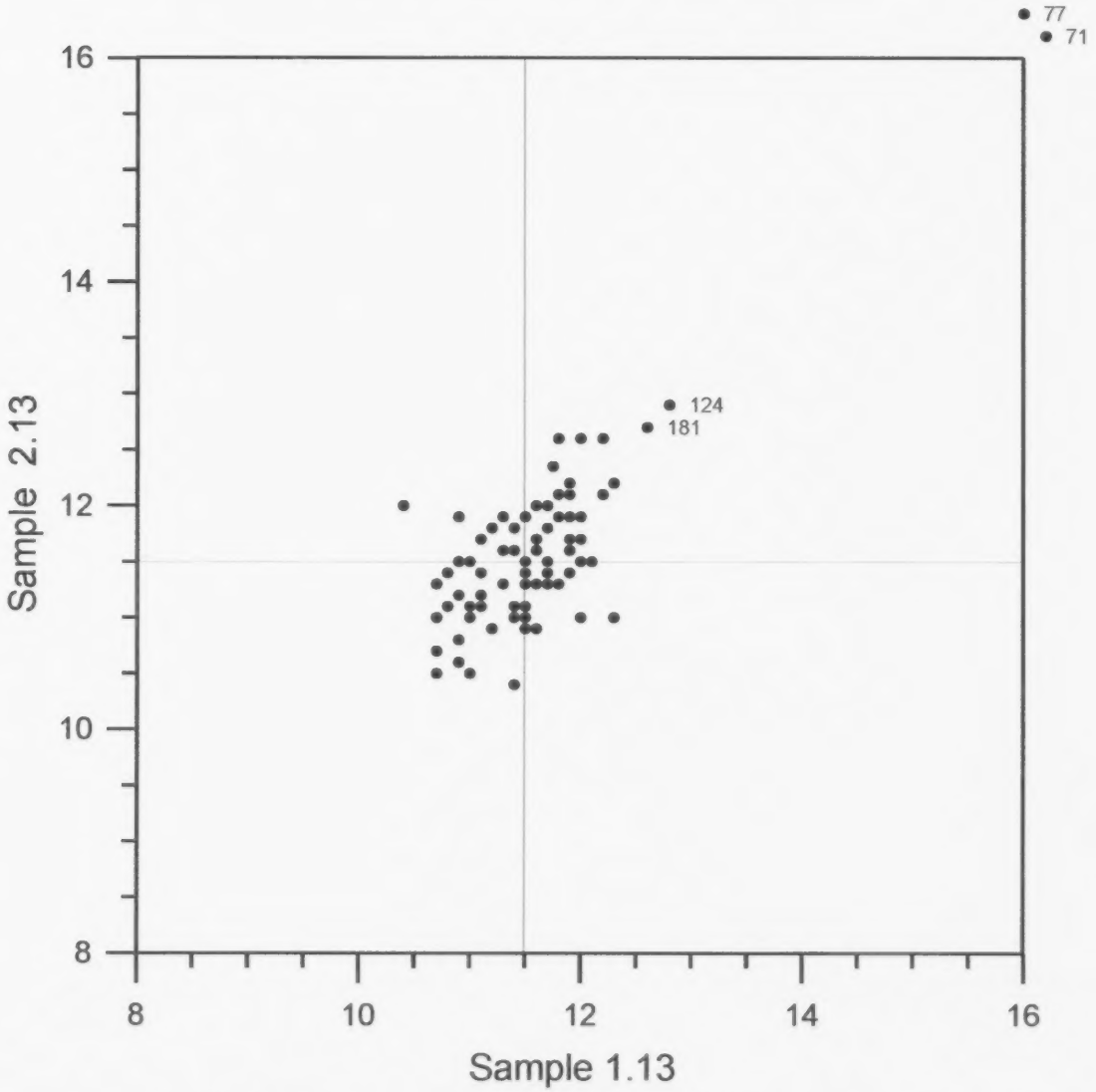


Test 14: Petrographic Number (Concrete)

	Mat 1	Mat 2
Mean	-	-
Median	-	-
Std Dev		

n = 35

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



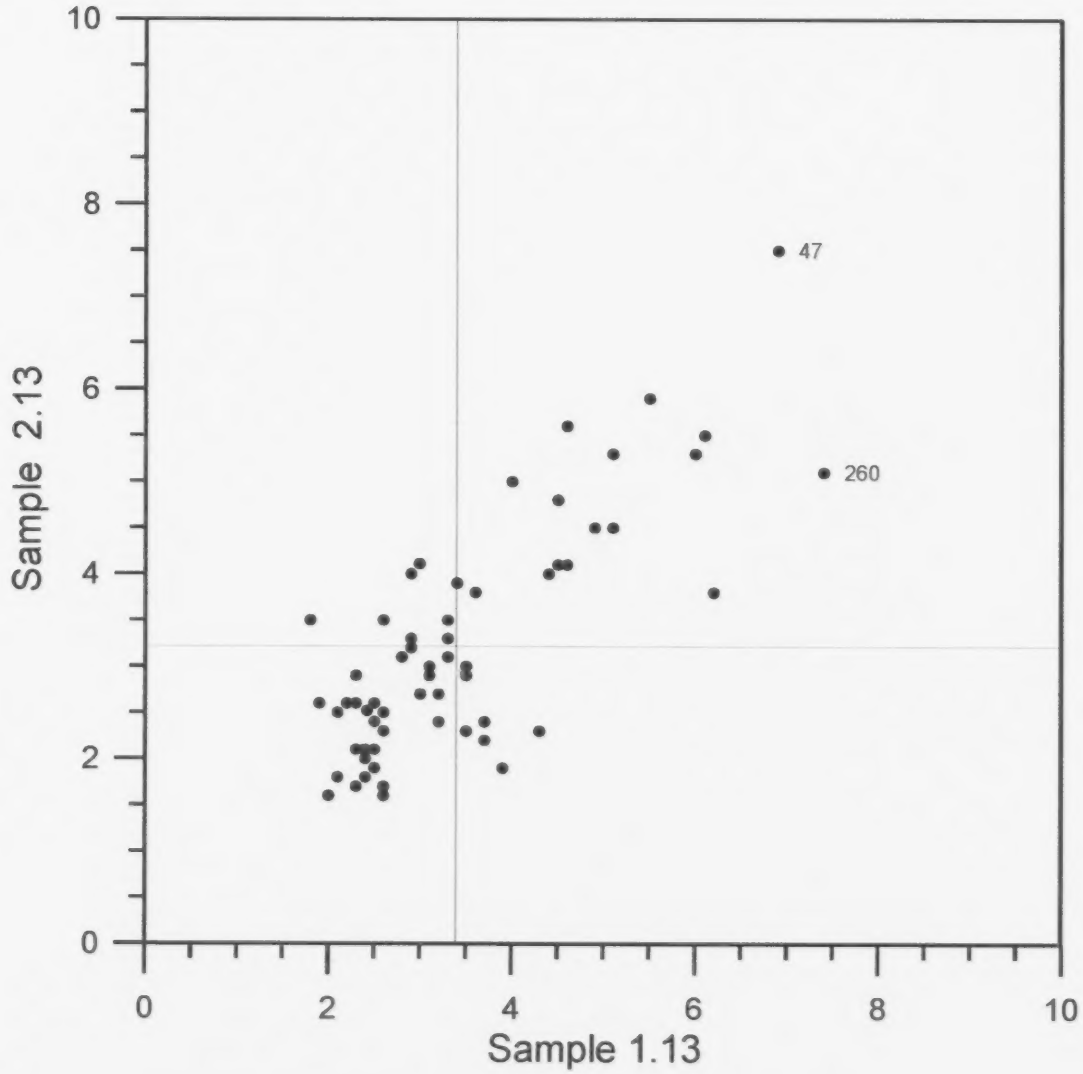
Test 16: Micro-Deval Abrasion Loss (CA), %

	Mat 1	Mat 2
Mean	11.472	11.514
Median	11.350	11.500
Std Dev	0.450	0.537

n = 76

Labs Eliminated: 71; 77; 124; 181

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



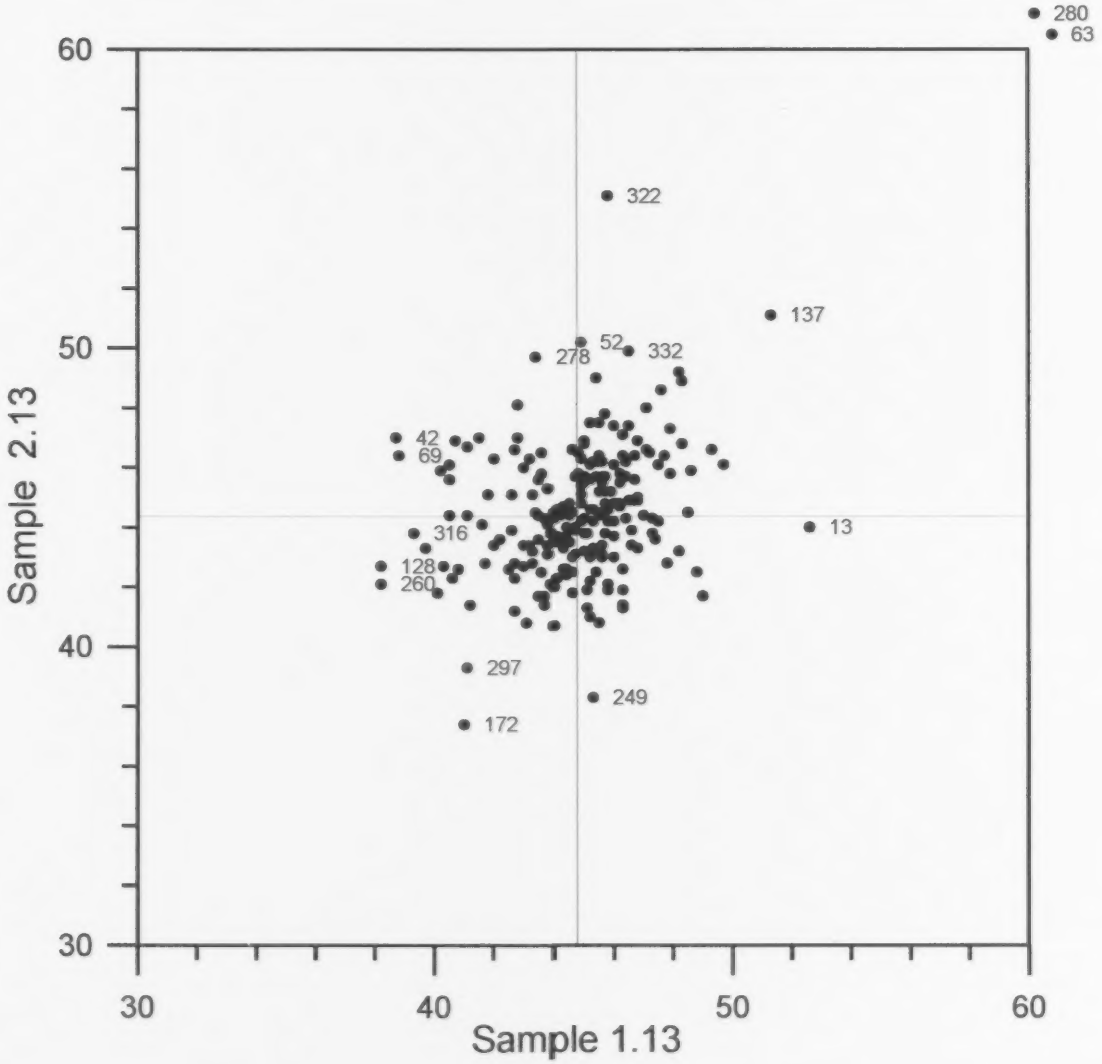
Test 17: Freeze-Thaw Loss, %

	Mat 1	Mat 2
Mean	3.304	3.160
Median	4.000	3.750
Std Dev	1.096	1.127

n = 60

Labs Eliminated: 47; 260

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



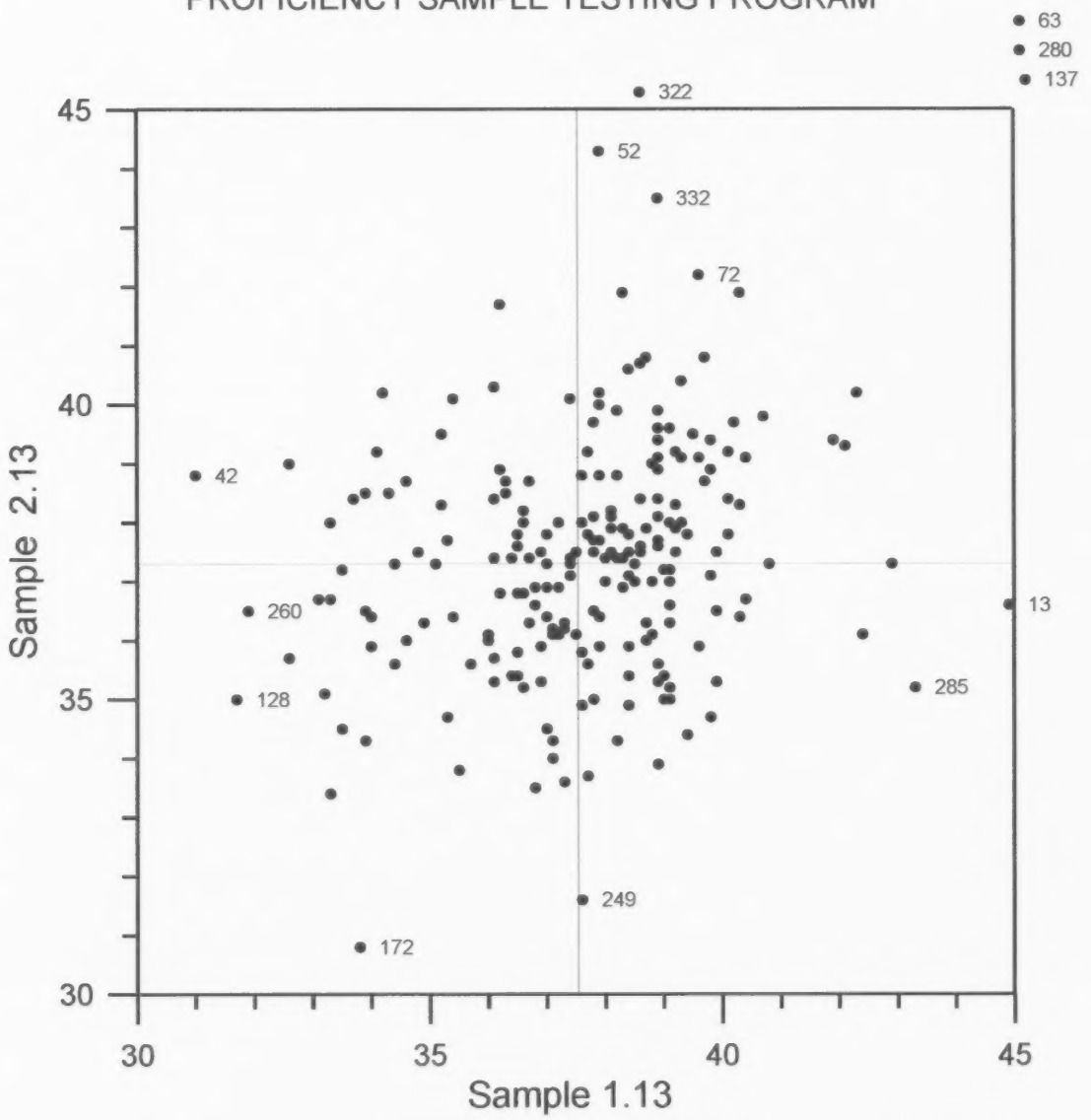
Test 20: Percent Passing the 2.36 mm Sieve

	Mat 1	Mat 2
Mean	44.871	44.490
Median	44.700	44.950
Std Dev	1.936	1.767

n = 207

Labs Eliminated: 13; 42; 52; 63; 69; 128; 137; 172; 249; 260; 278; 280; 297; 316; 322; 332

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



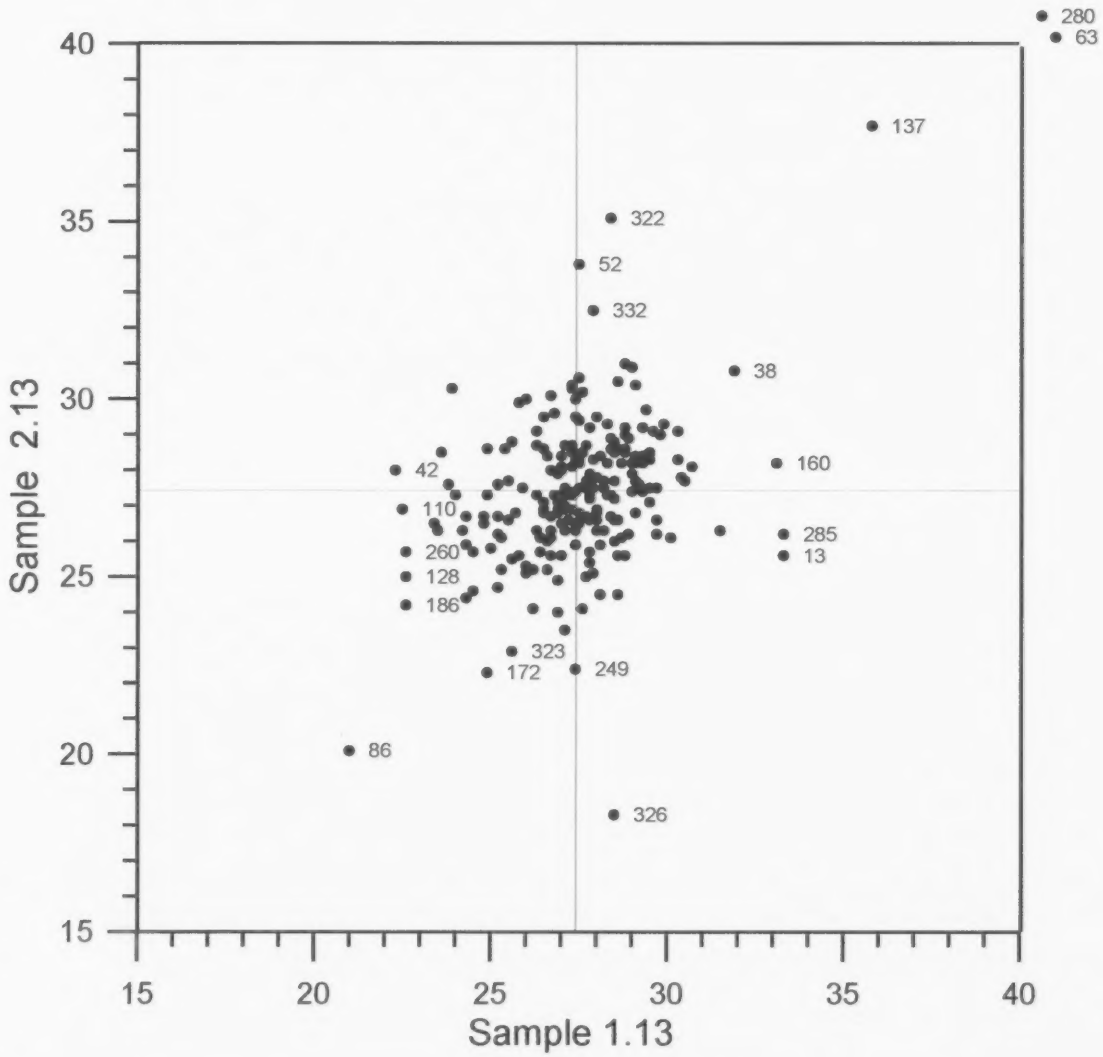
Test 21: Percent Passing the 1.18 mm Sieve

	Mat 1	Mat 2
Mean	37.622	37.324
Median	37.750	37.650
Std Dev	1.950	1.720

n = 209

Labs Eliminated: 13; 42; 52; 63; 72; 128; 137; 172; 249; 260; 280; 285; 322; 332

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



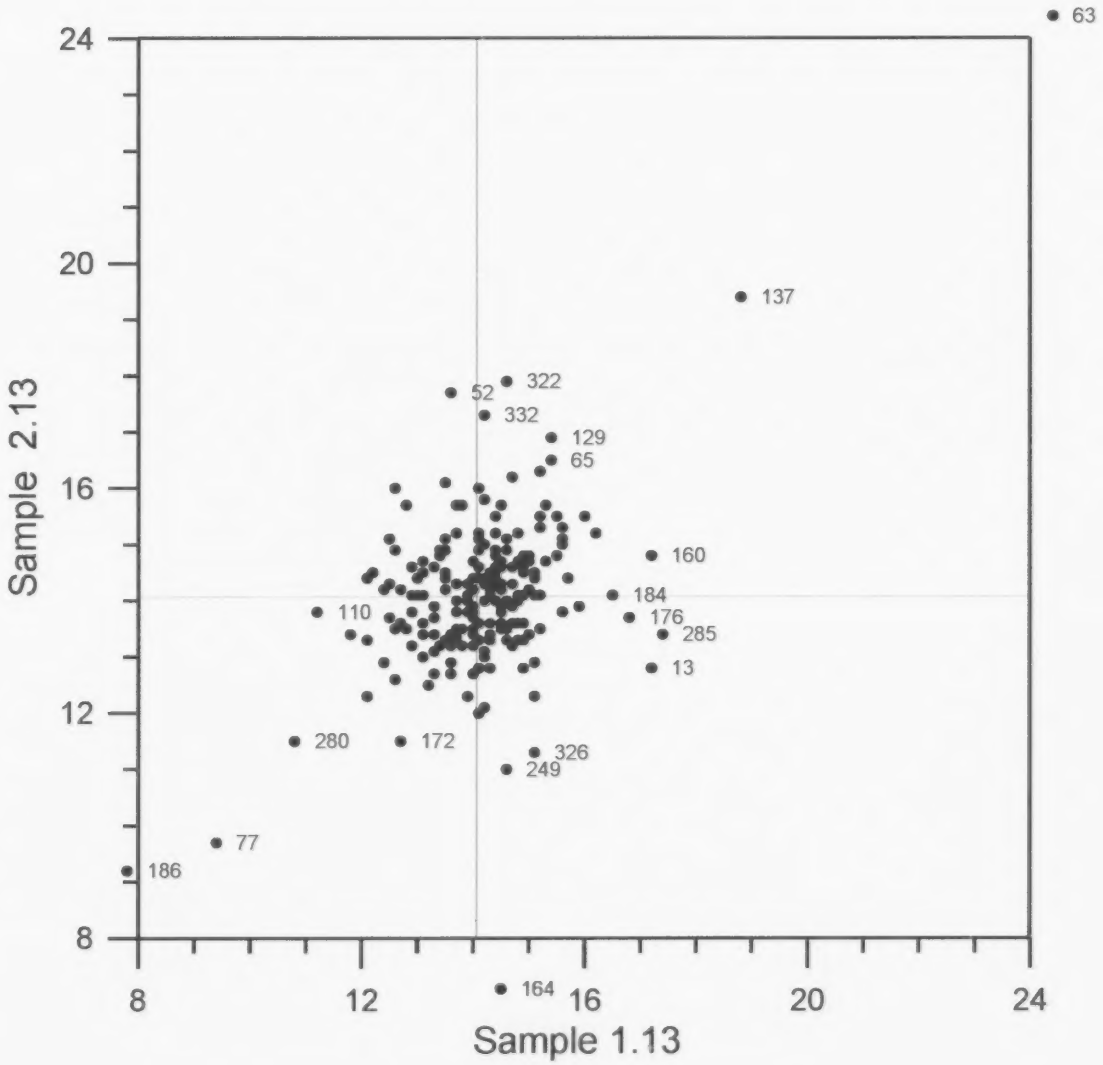
Test 22: Percent Passing the 600 um Sieve

	Mat 1	Mat 2
Mean	27.408	27.368
Median	27.450	27.250
Std Dev	1.525	1.494

n = 203

Labs Eliminated: 13; 38; 42; 52; 63; 86; 110; 128; 137; 160; 172; 186; 249; 260; 280; 285; 322; 323; 326; 332

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



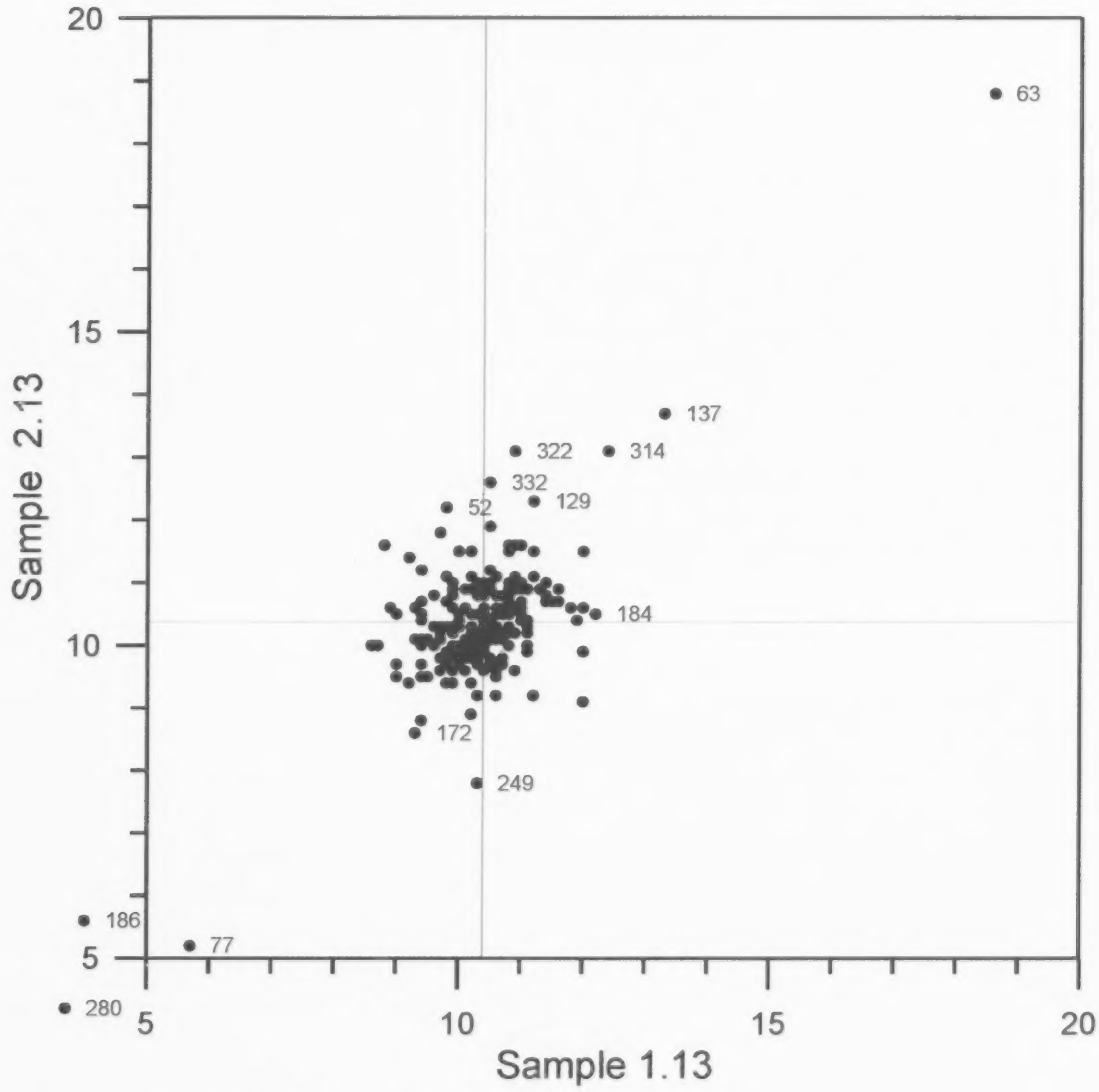
Test 23: Percent Passing the 300 um Sieve

	Mat 1	Mat 2
Mean	14.069	14.100
Median	14.000	14.150
Std Dev	0.843	0.847

n = 203

Labs Eliminated: 13; 52; 63; 65; 77; 110; 129; 137; 160; 164; 172; 176; 184; 186; 249; 280; 285; 322; 326; 332

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



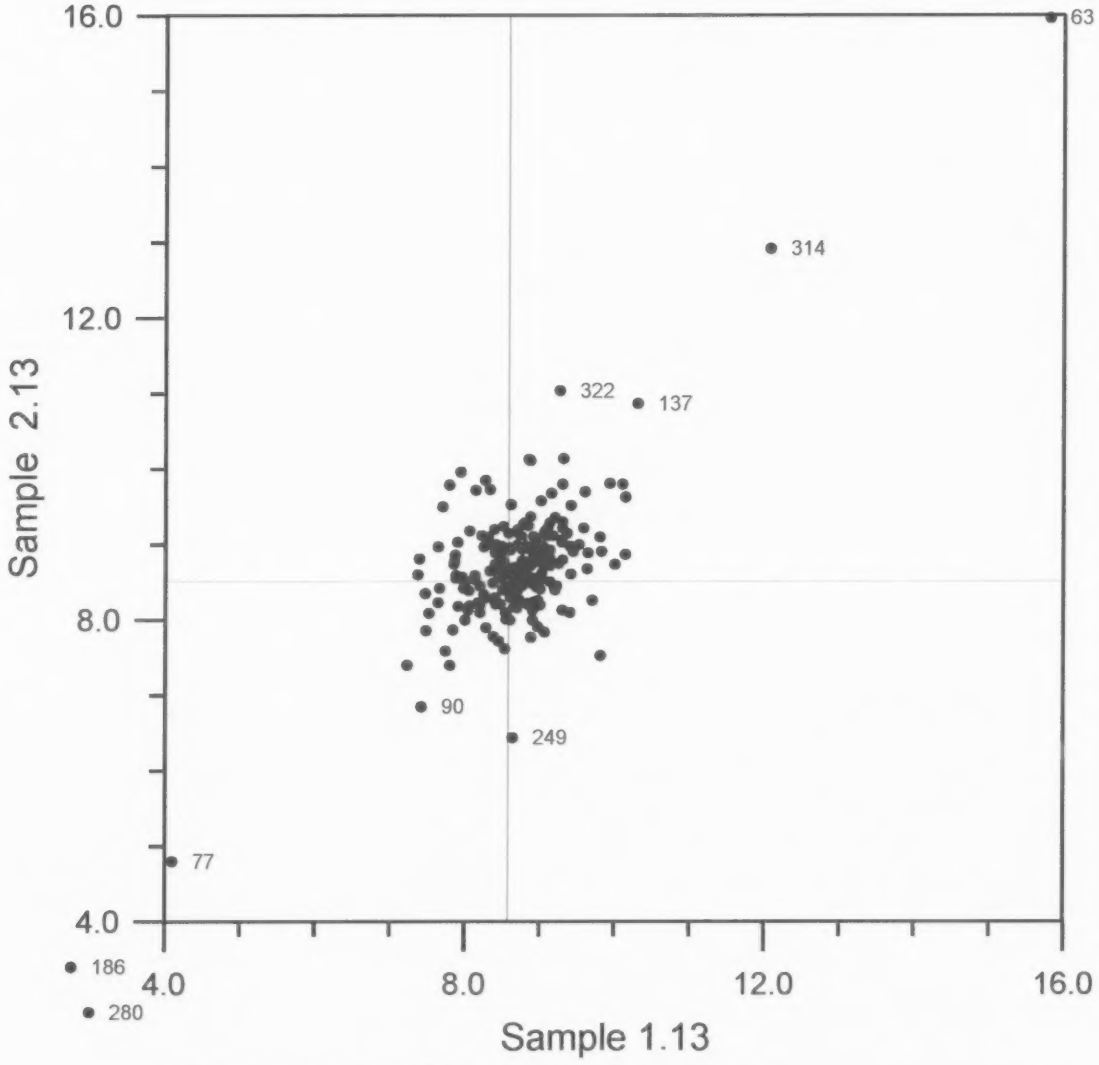
Test 24: Percent Passing the 150 um Sieve

	Mat 1	Mat 2
Mean	10.321	10.336
Median	10.300	10.350
Std Dev	0.651	0.575

n = 210

Labs Eliminated: 52; 63; 77; 129; 137; 172; 184; 186; 249; 280; 314; 322; 332

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



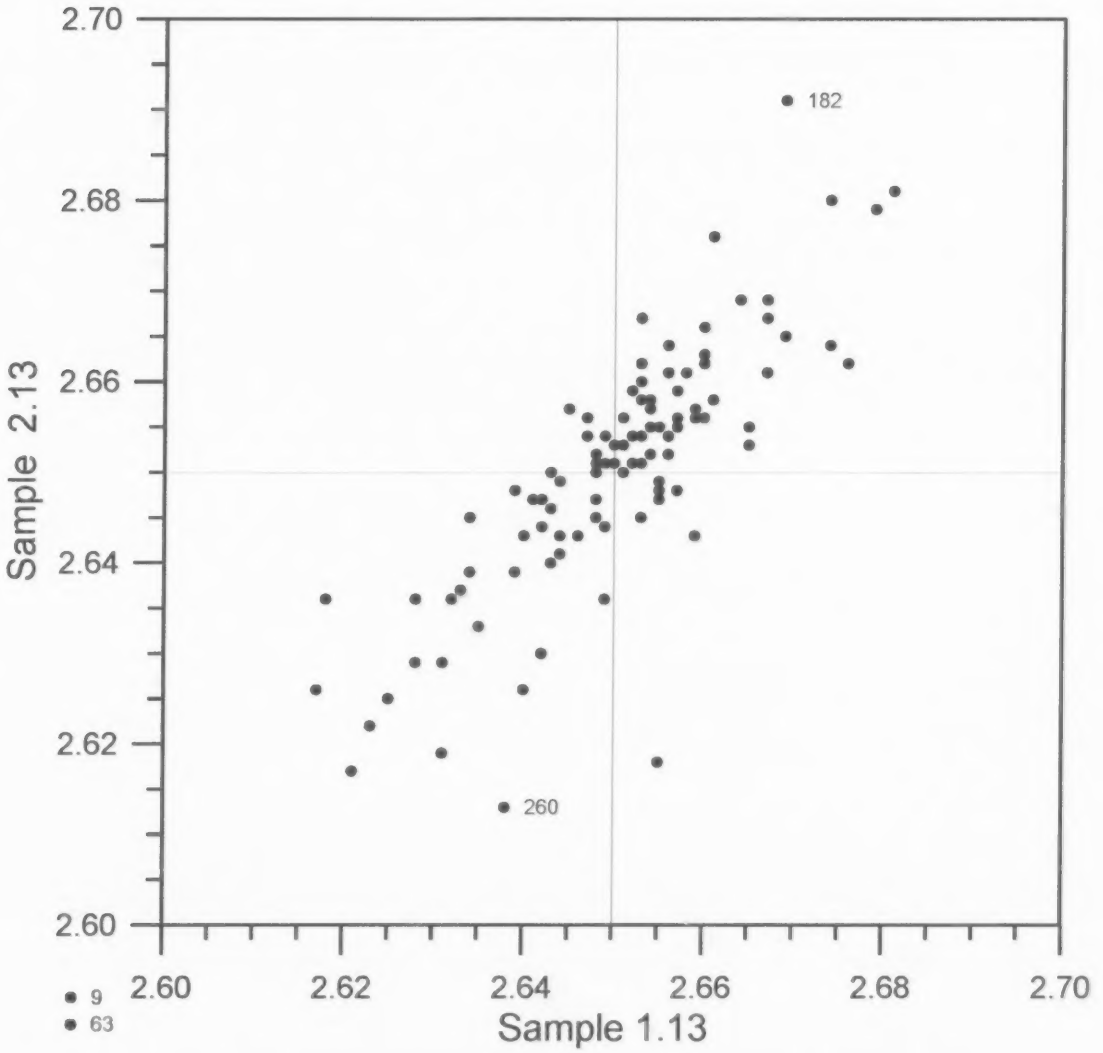
Test 25: Percent Passing the 75 um Sieve

	Mat 1	Mat 2
Mean	8.689	8.714
Median	8.685	8.770
Std Dev	0.550	0.517

n = 214

Labs Eliminated: 63; 77; 90; 137; 186; 249; 280; 314; 322

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



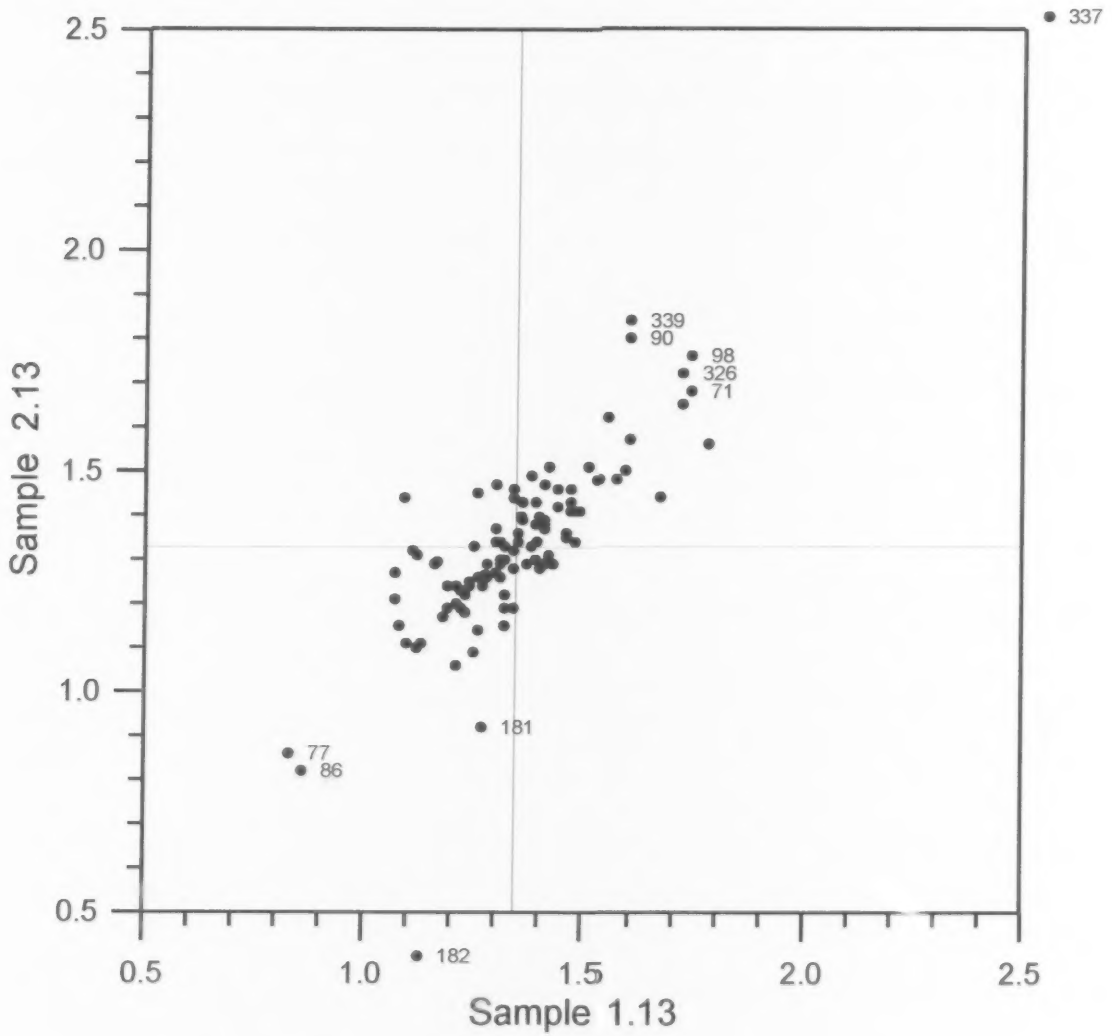
Test 27: Relative Density of Fine Aggregate (O. D)

	Mat 1	Mat 2
Mean	2.650	2.650
Median	2.649	2.649
Std Dev	0.013	0.013

n = 99

Labs Eliminated: 9; 63; 182; 260

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



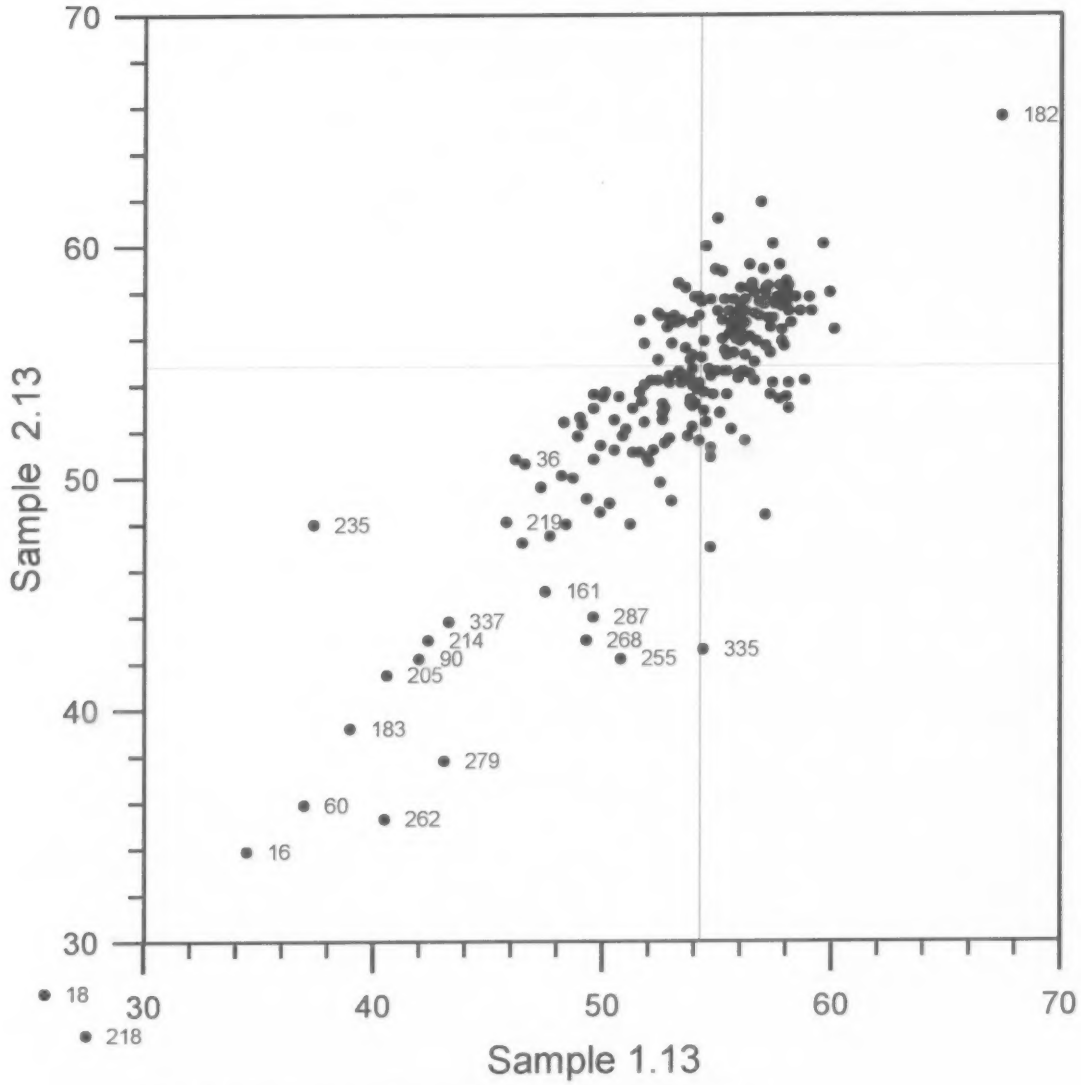
Test 28: Absorption of Fine Aggregate

	Mat 1	Mat 2
Mean	1.351	1.329
Median	1.425	1.355
Std Dev	0.157	0.122

n = 93

Labs Eliminated: 71; 77; 86; 90; 98; 181; 182; 326; 337; 339

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



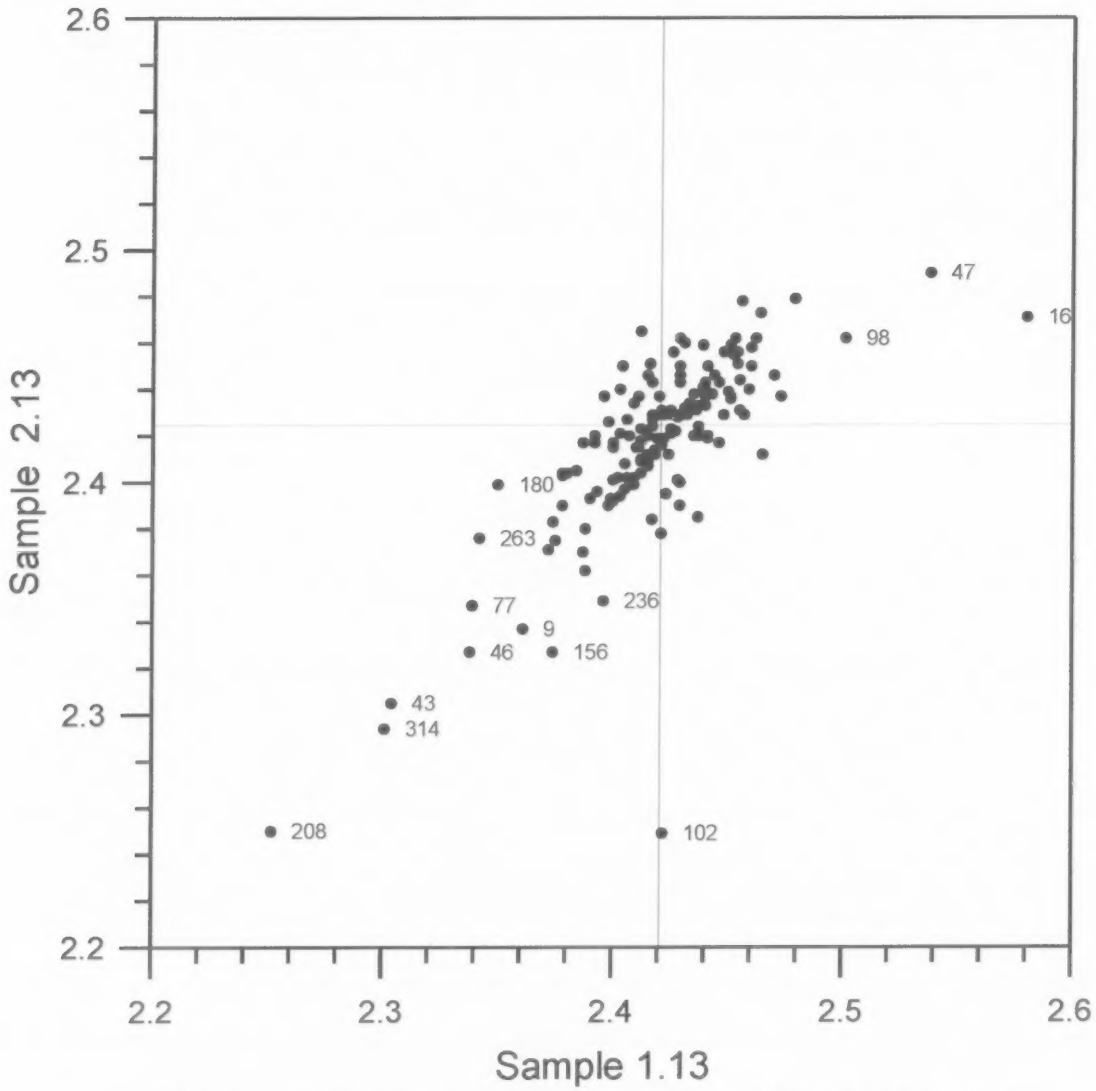
Test 30: Percent Asphalt Coated Particles

	Mat 1	Mat 2
Mean	54.433	54.833
Median	53.300	54.450
Std Dev	2.874	2.957

n = 202

Labs Eliminated: 16; 18; 36; 60; 90; 161; 182; 183; 205; 214; 218; 219; 235; 255; 262; 268; 279; 287; 335; 337

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



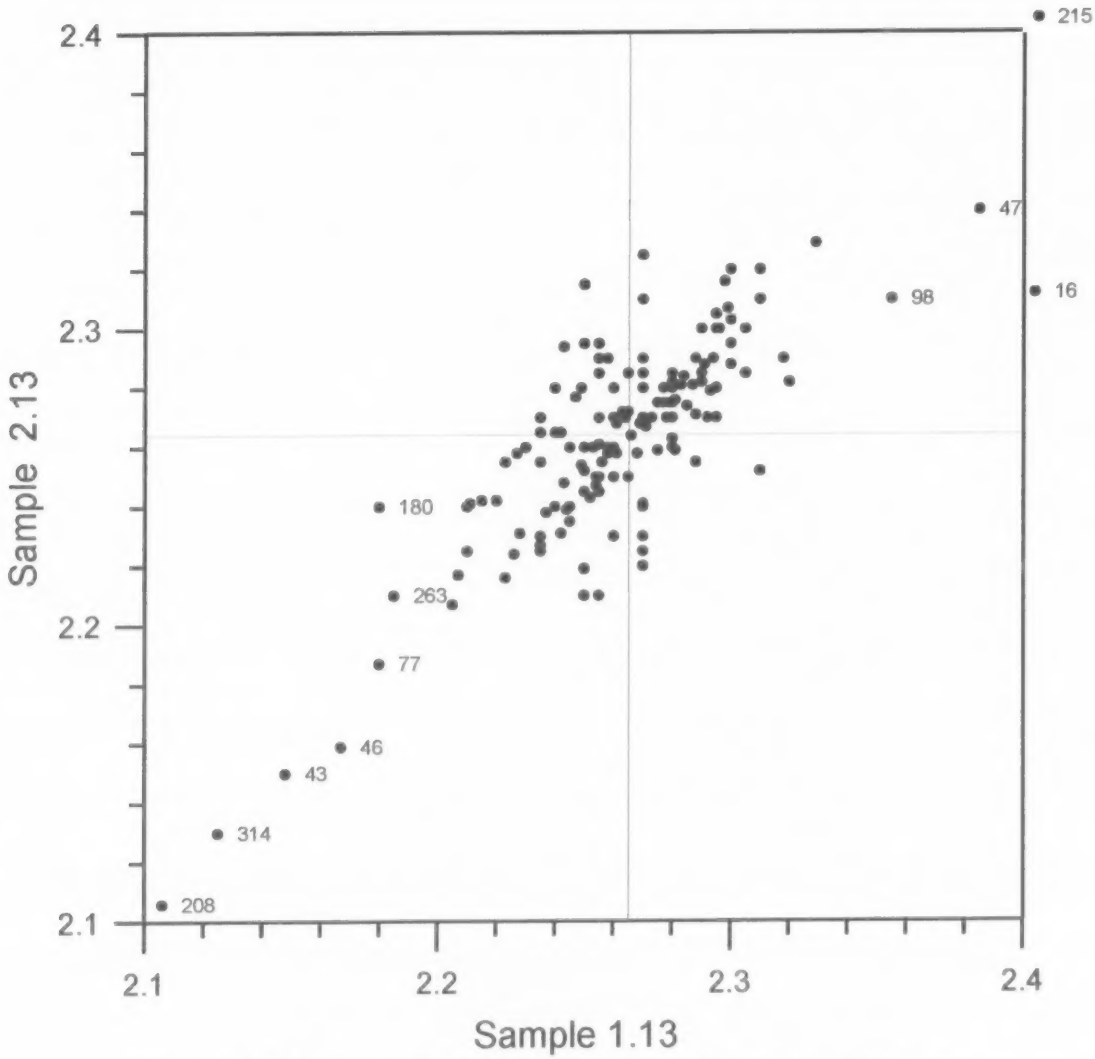
Test 31: Maximum Wet Density g/cm3 (Moisture-Density)

	Mat 1	Mat 2
Mean	2.422	2.425
Median	2.426	2.421
Std Dev	0.024	0.024

n = 141

Labs Eliminated: 9; 16; 43; 46; 47; 77; 98; 102; 156; 180; 208; 236; 263; 314

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



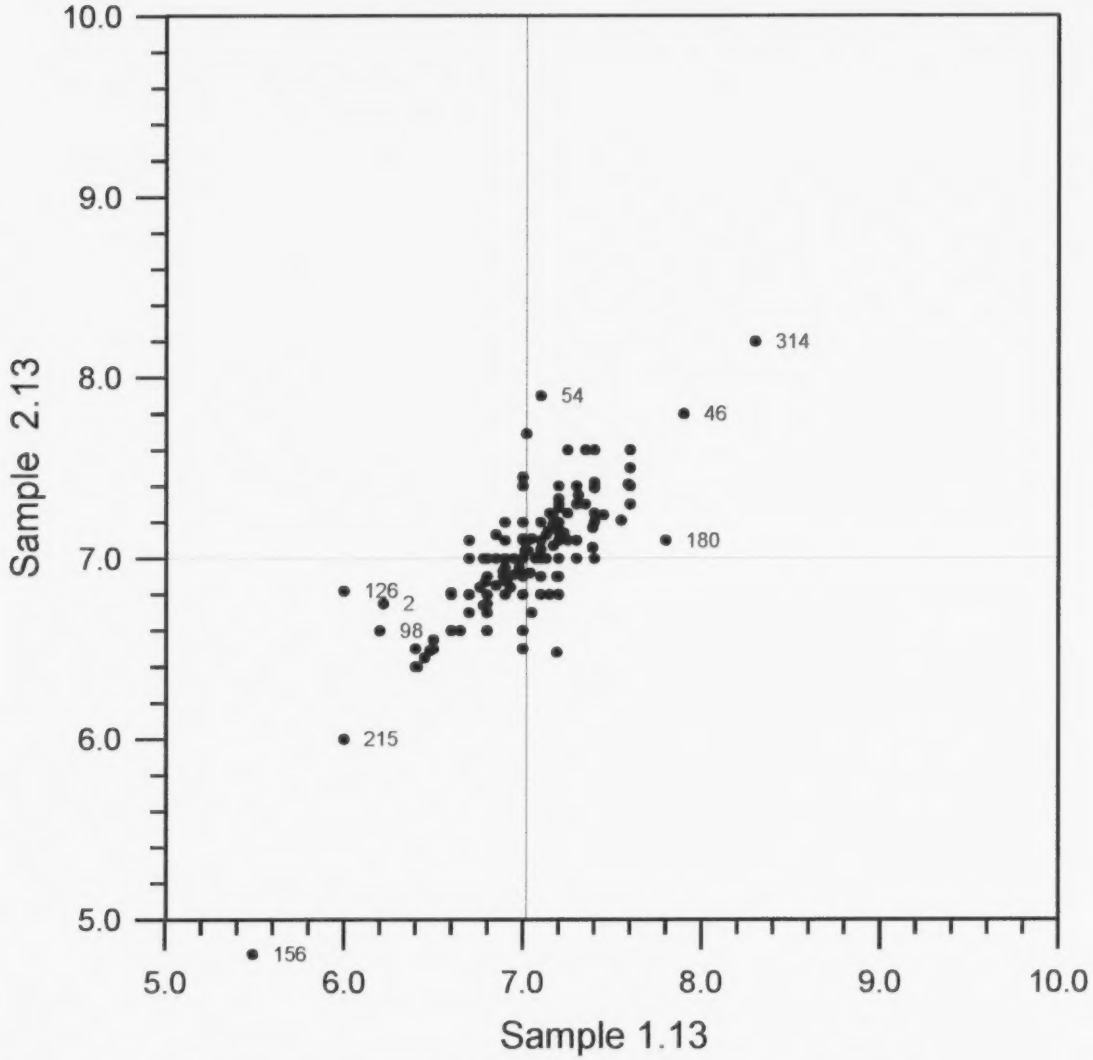
Test 32: Maximum Dry Density g/cm3 (Moisture-Density)

	Mat 1	Mat 2
Mean	2.265	2.267
Median	2.267	2.268
Std Dev	0.025	0.027

n = 144

Labs Eliminated: 16; 43; 46; 47; 77; 98; 180; 208; 215; 263; 314

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



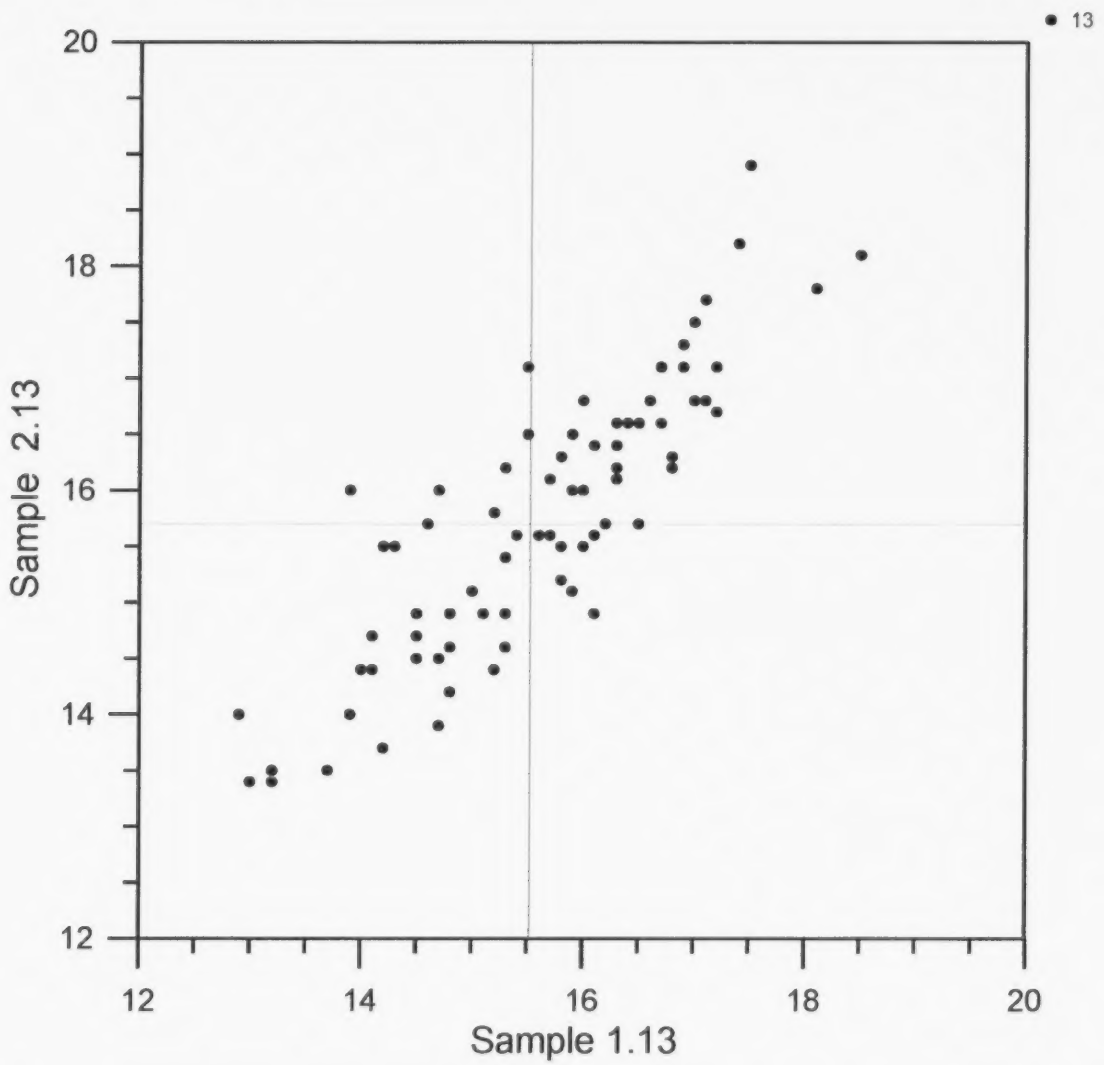
Test 33: Optimum Moisture, % (Moisture - Density)

	Mat 1	Mat 2
Mean	7.046	7.021
Median	7.000	7.045
Std Dev	0.260	0.264

n = 146

Labs Eliminated: 2; 46; 54; 98; 126; 156; 180; 215; 314

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



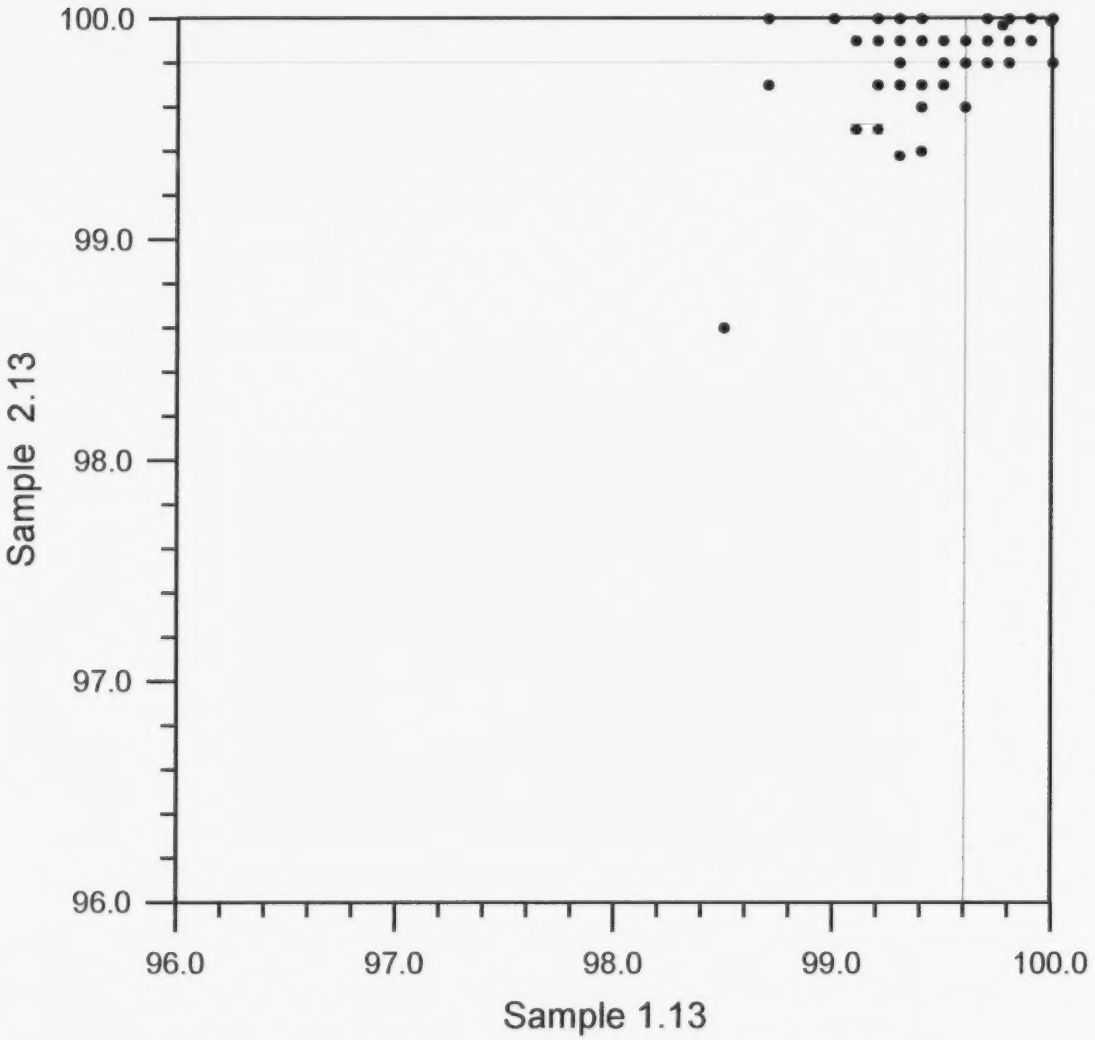
Test 34: Micro-Deval Abrasion Loss (FA), %

	Mat 1	Mat 2
Mean	15.609	15.741
Median	15.700	16.150
Std Dev	1.205	1.210

n = 79

Lab Eliminated: 13;

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



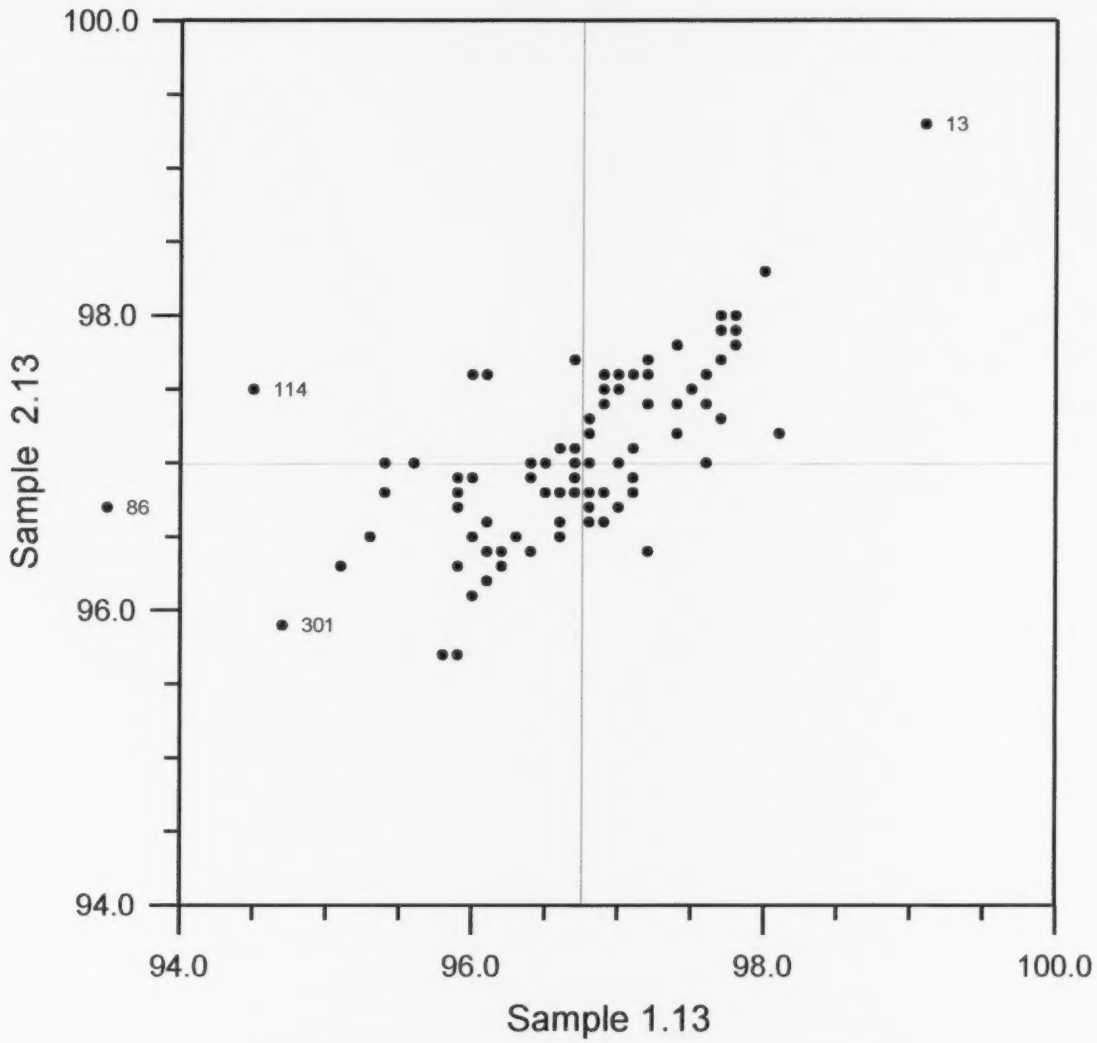
Test 40: Percent Passing the 2.00 mm Sieve (Soil)

	Mat 1	Mat 2
Mean	99.594	99.852
Median	99.250	99.300
Std Dev	0.319	0.193

n = 90

Labs Eliminated: None

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



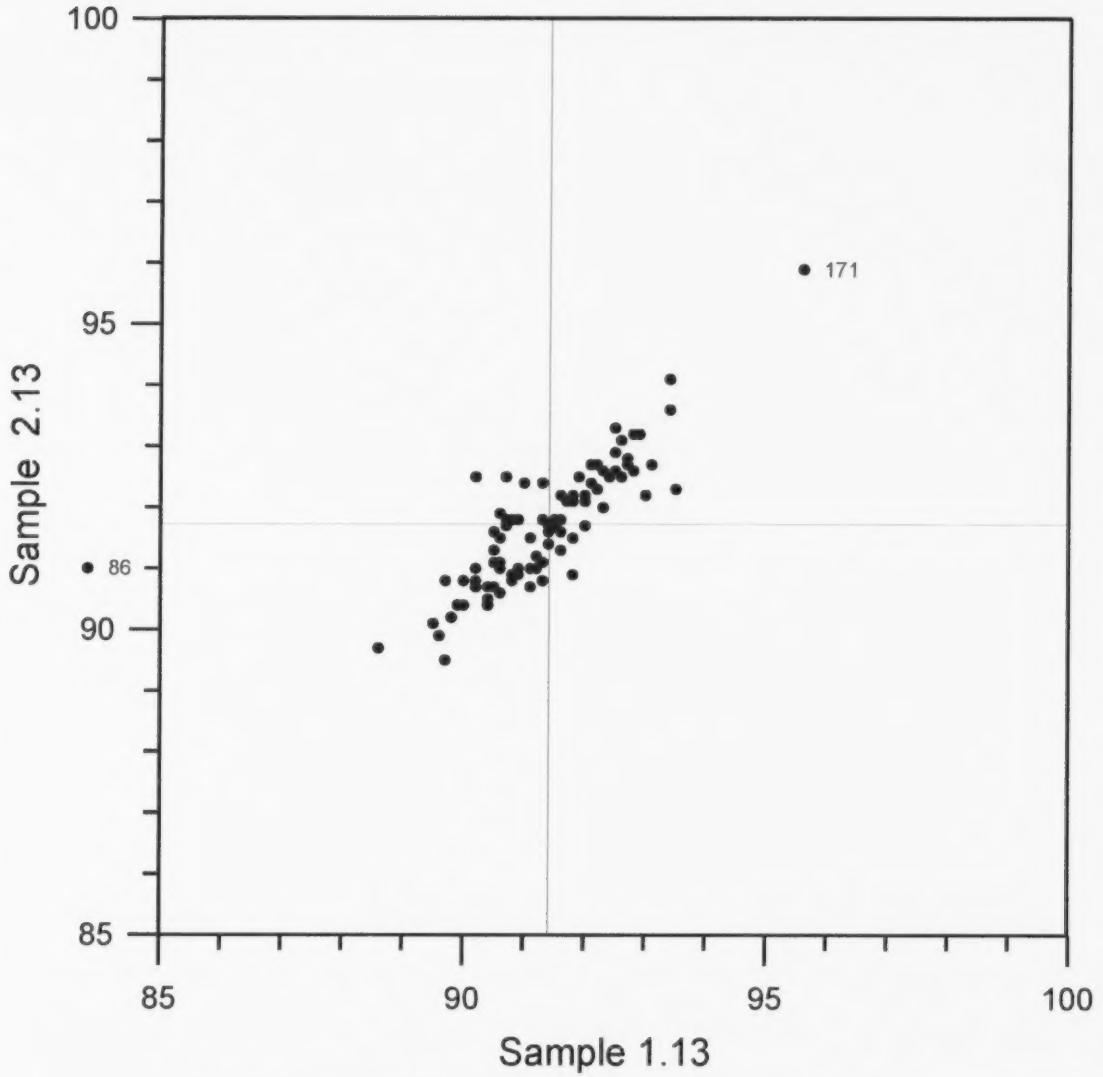
Test 41: Percent Passing the 425 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	96.701	96.997
Median	96.600	97.000
Std Dev	0.676	0.544

n = 86

Labs Eliminated: 13; 86; 114; 301

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



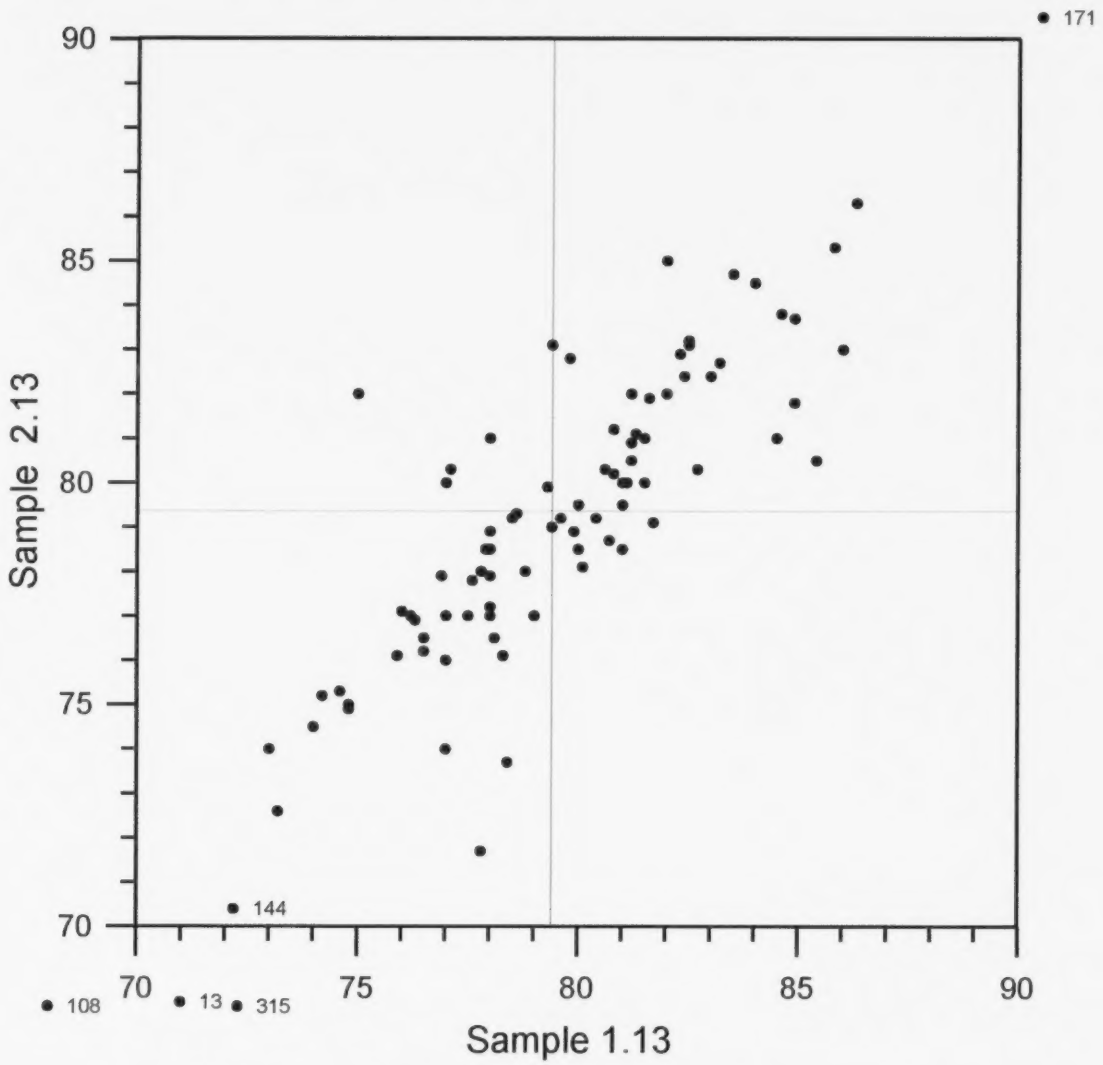
Test 42: Percent Passing the 75 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	91.350	91.667
Median	91.050	91.800
Std Dev	1.015	0.921

n = 88

Labs Eliminated: 86; 171

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



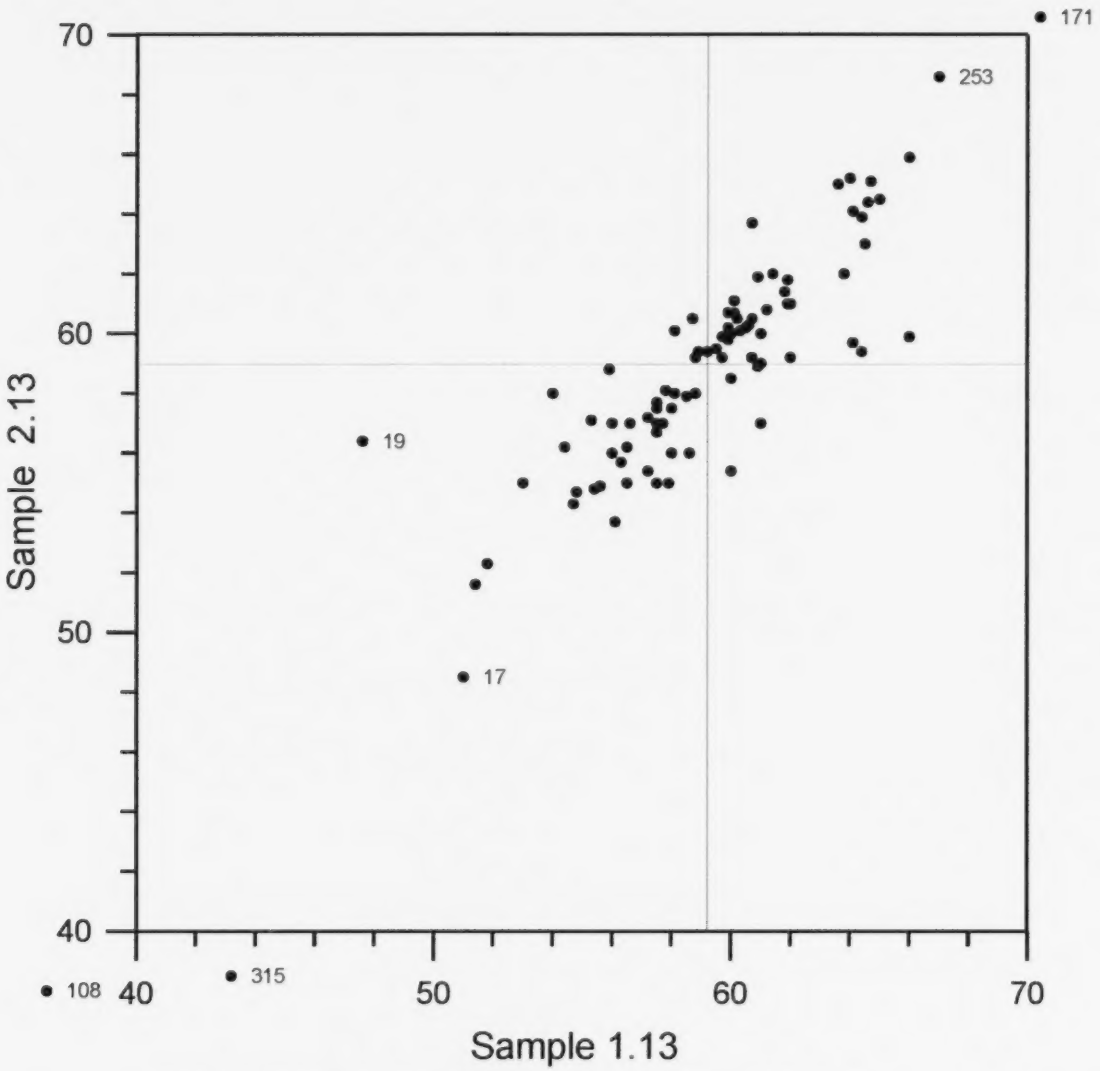
Test 43: Percent Passing the 20 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	79.325	79.282
Median	79.650	79.000
Std Dev	3.361	3.069

n = 85

Labs Eliminated: 13; 108; 144; 171; 315

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



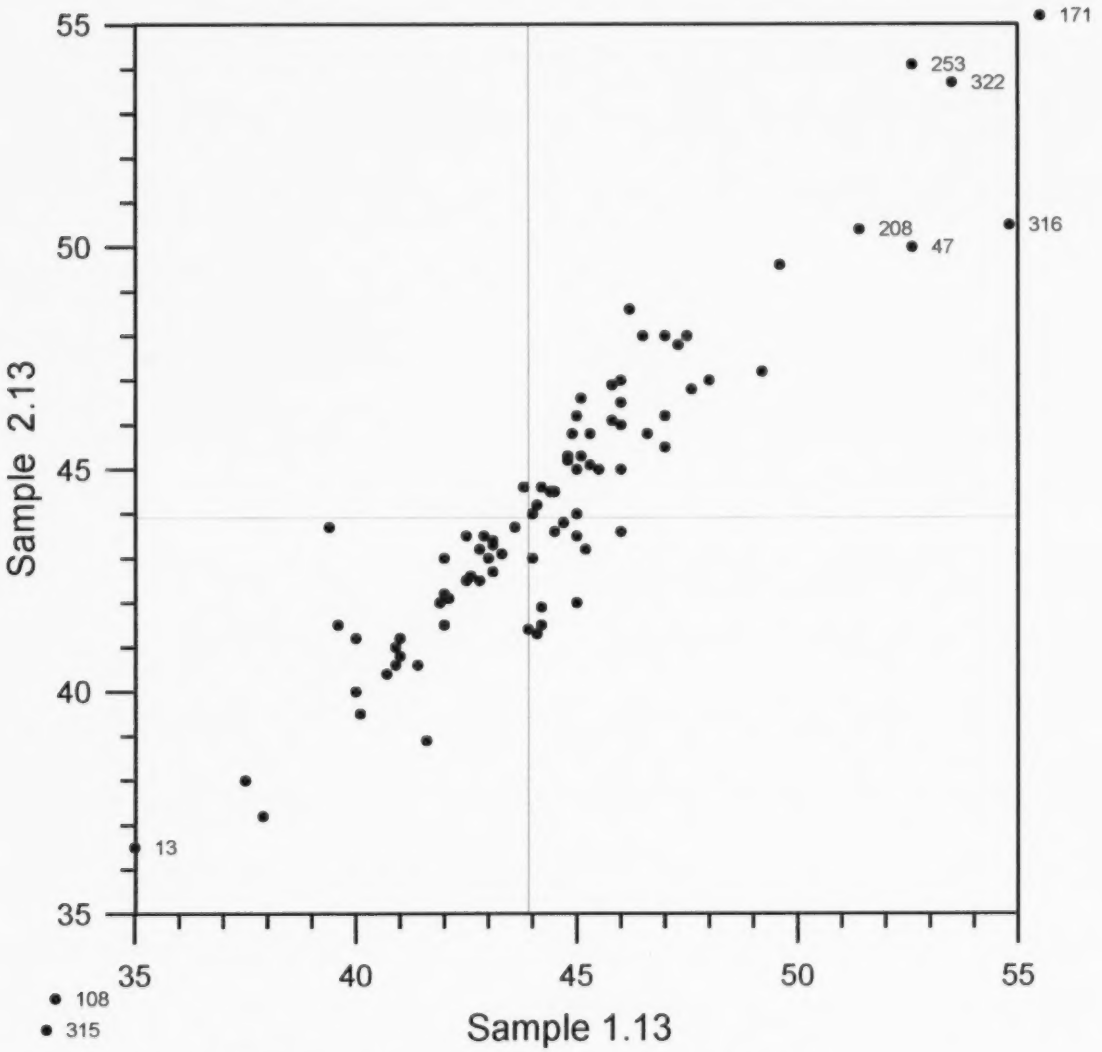
Test 44: Percent Passing the 5 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	59.395	58.940
Median	58.700	58.750
Std Dev	3.403	3.065

n = 84

Labs Eliminated: 17; 19; 108; 171; 253; 315

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



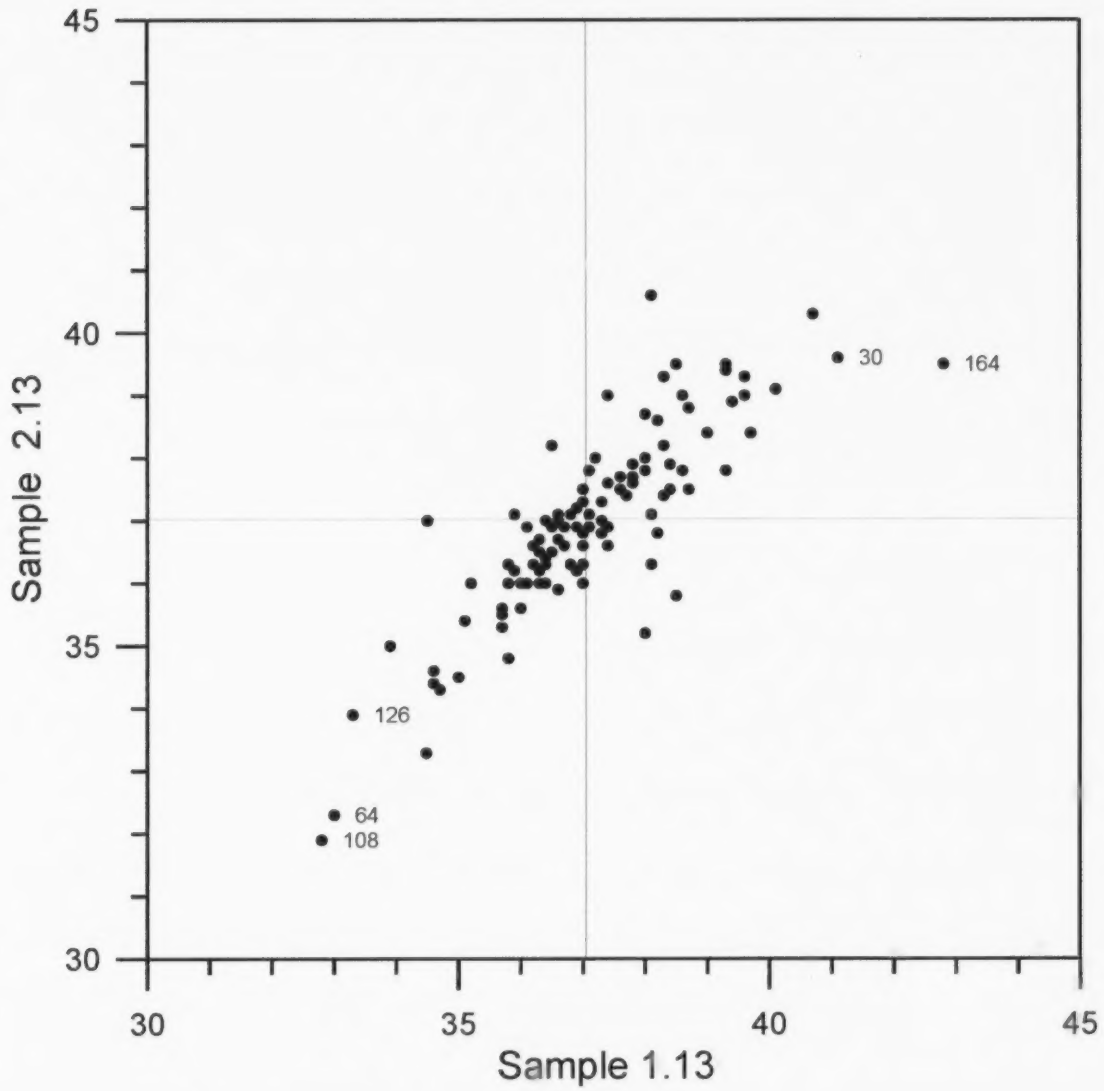
Test 45: Percent Passing the 2 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	43.901	43.900
Median	43.550	43.400
Std Dev	2.422	2.834

n = 81

Labs Eliminated: 13; 47; 108; 171; 208; 253; 315; 316; 322

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



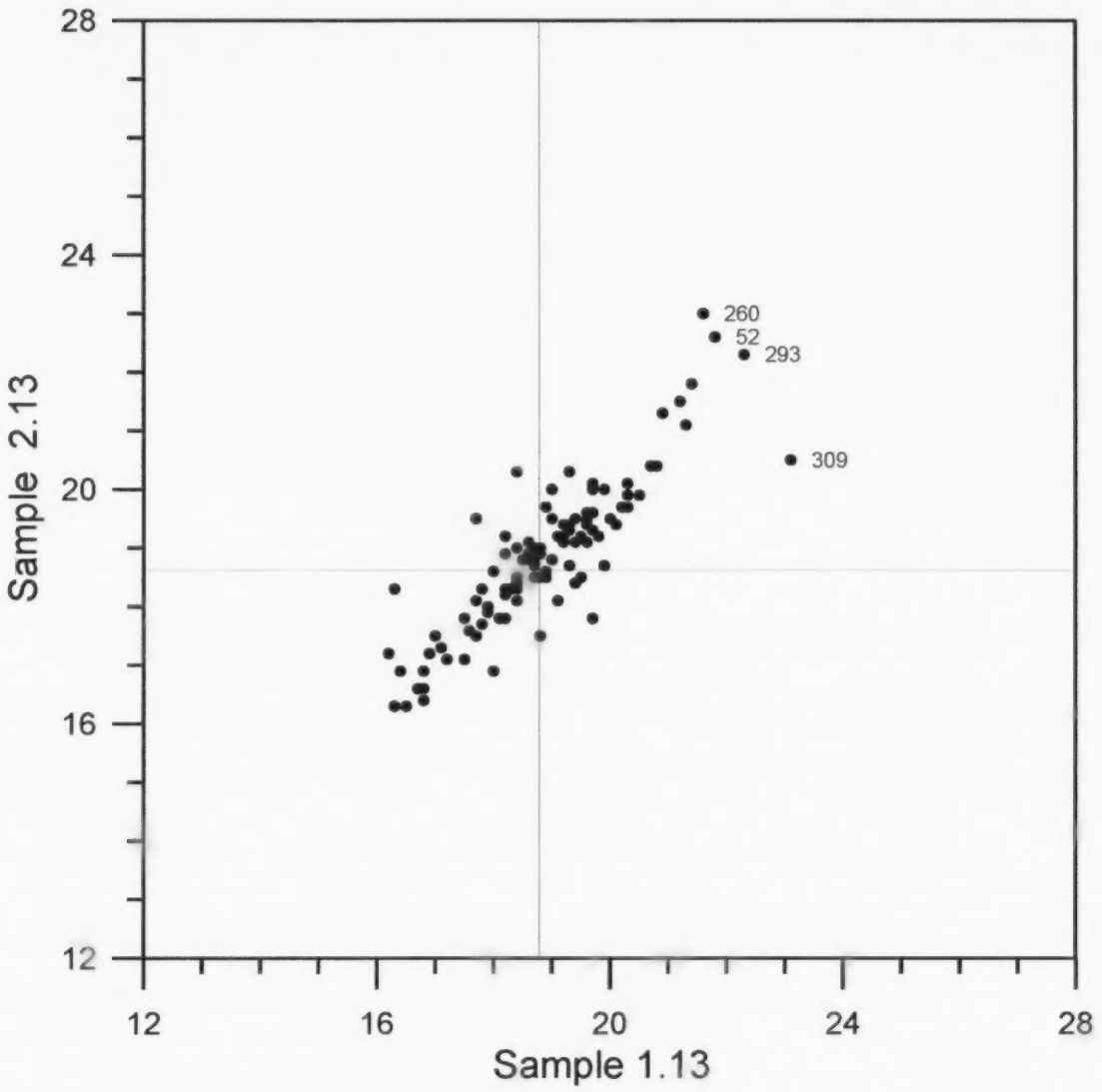
Test 46: Liquid Limit, %

	Mat 1	Mat 2
Mean	37.144	37.069
Median	37.300	36.945
Std Dev	1.329	1.385

n = 103

Labs Eliminated: 30; 64; 108; 126; 164

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



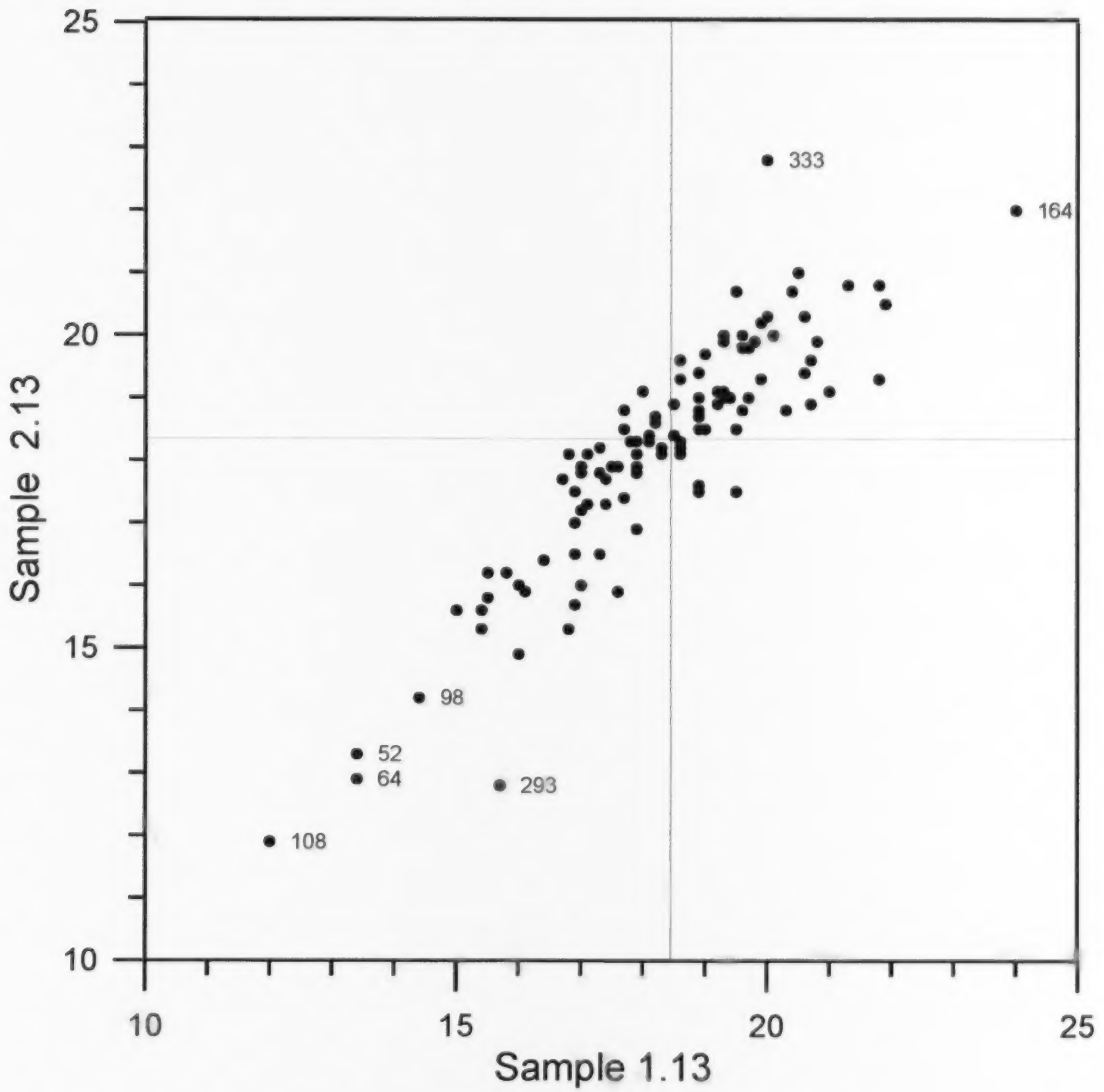
Test 47: Plastic Limit, %

	Mat 1	Mat 2
Mean	18.813	18.734
Median	18.800	19.050
Std Dev	1.274	1.142

n = 104

Labs Eliminated: 52; 260; 293; 309

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



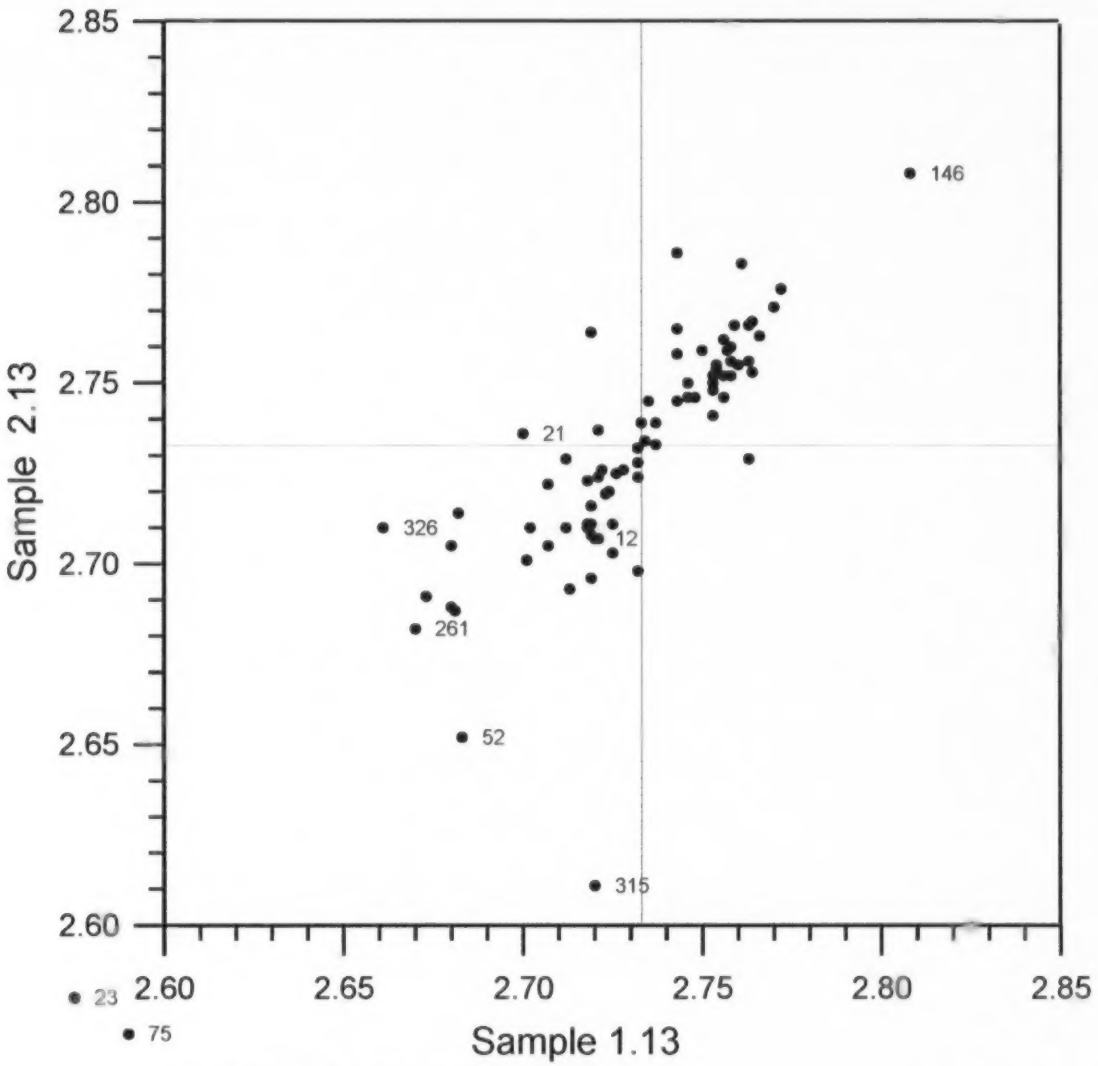
Test 48: Plasticity Index, %

	Mat 1	Mat 2
Mean	18.369	18.341
Median	18.450	17.950
Std Dev	1.594	1.447

n = 101

Labs Eliminated: 52; 64; 98; 108; 164; 293; 333

2013 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 49: Specific Gravity of Soil

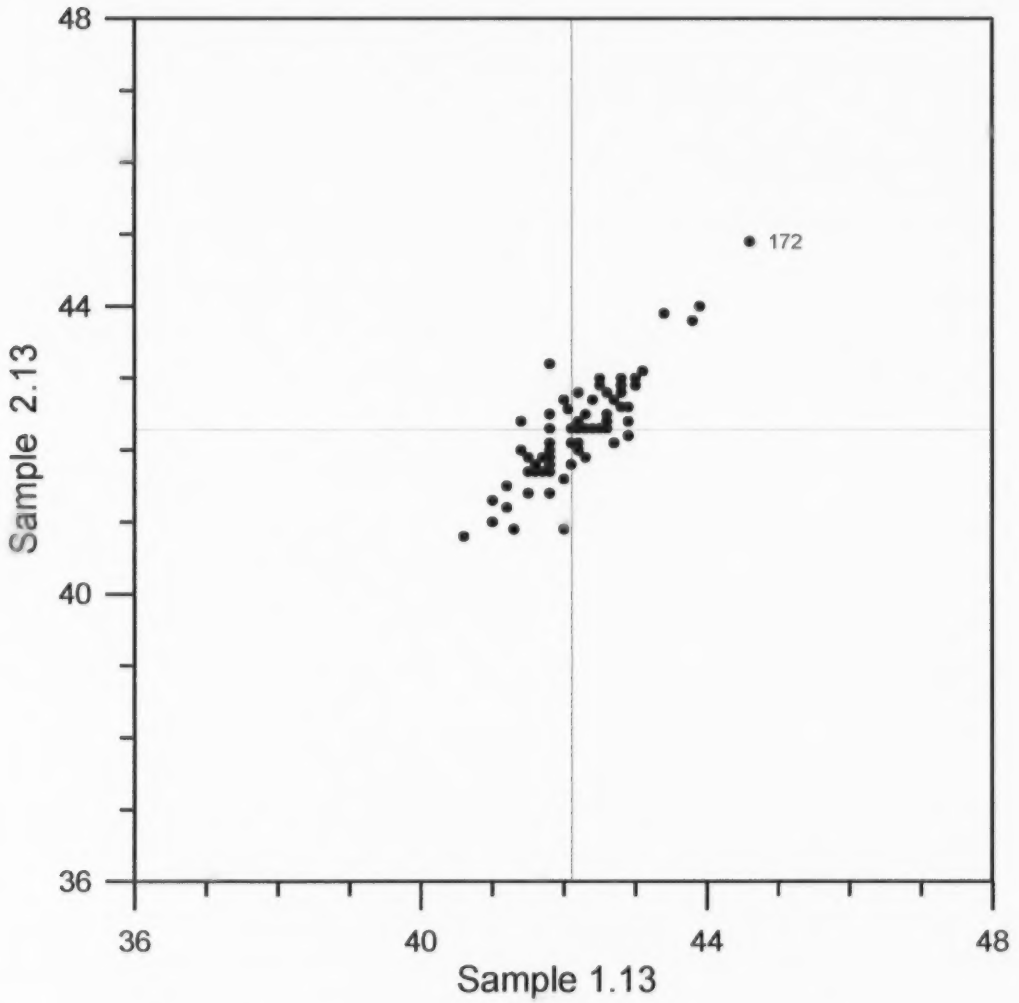
	Mat 1	Mat 2
Mean	2.733	2.734
Median	2.723	2.737
Std Dev	0.024	0.025

n = 74

Labs Eliminated: 12; 21; 23; 52; 75; 146; 261; 315; 326

Appendix D2: Scatter Diagrams

2013 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



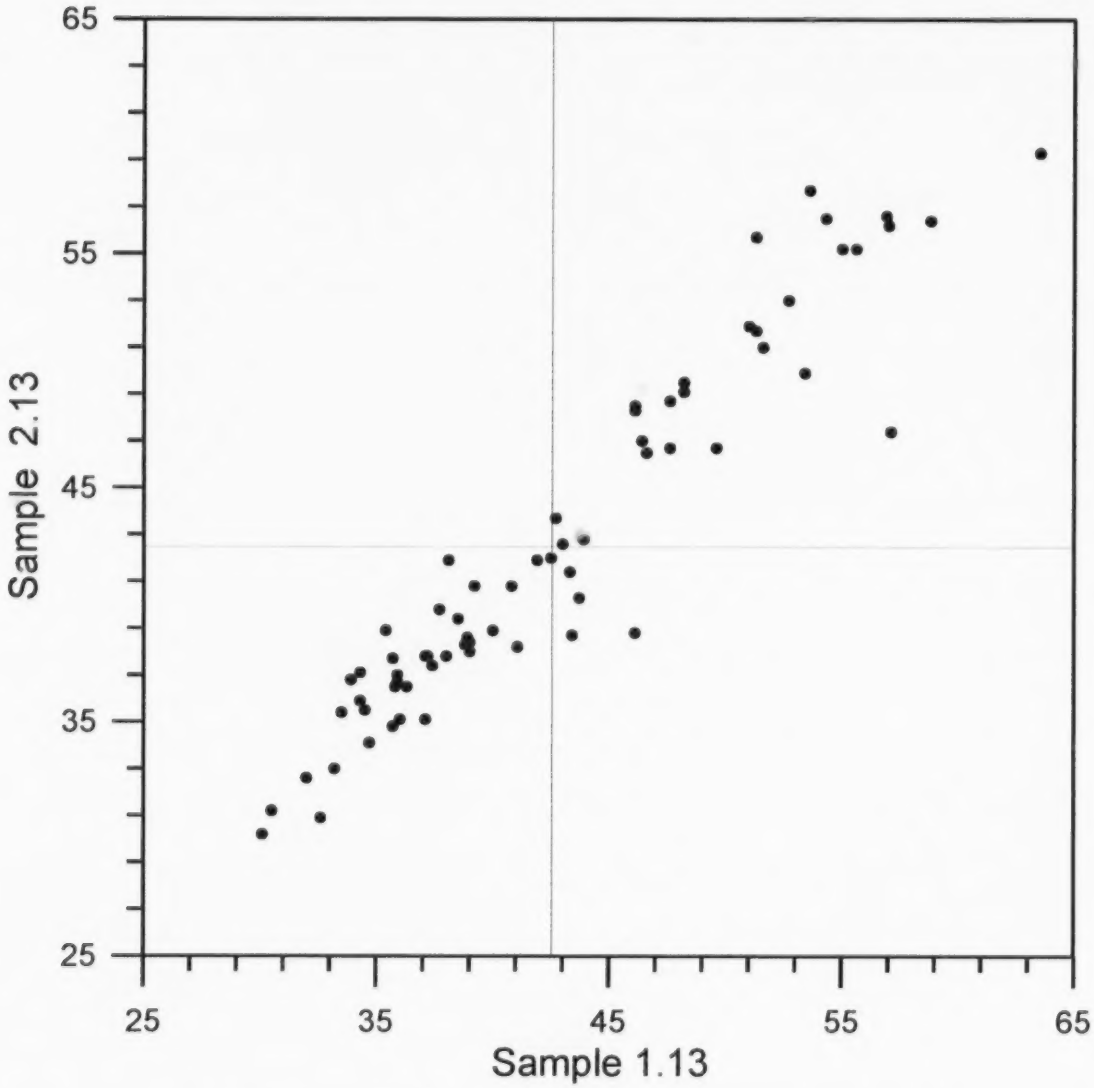
Test 95: Uncompacted Void Content of Fine Aggregate

	Mat 1	Mat 2
Mean	42.206	42.270
Median	42.250	42.400
Std Dev	0.638	0.655

n = 71

Lab Eliminated: 172

2013 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



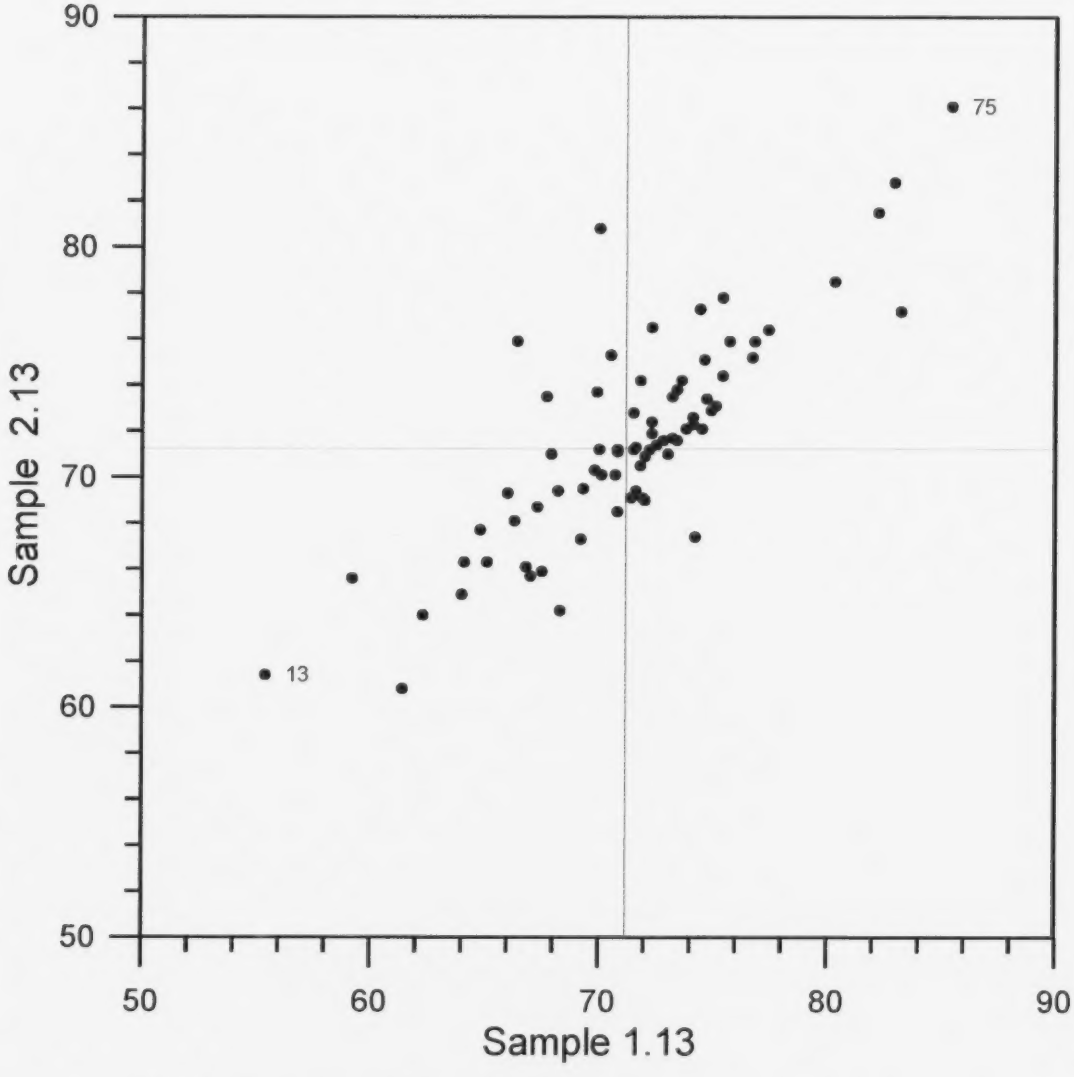
Test 96: Sand Equivalent Value of Fine Aggregate

	Mat 1	Mat 2
Mean	42.767	42.674
Median	46.800	44.750
Std Dev	8.036	7.689

n = 68

Labs Eliminated: None

2013 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



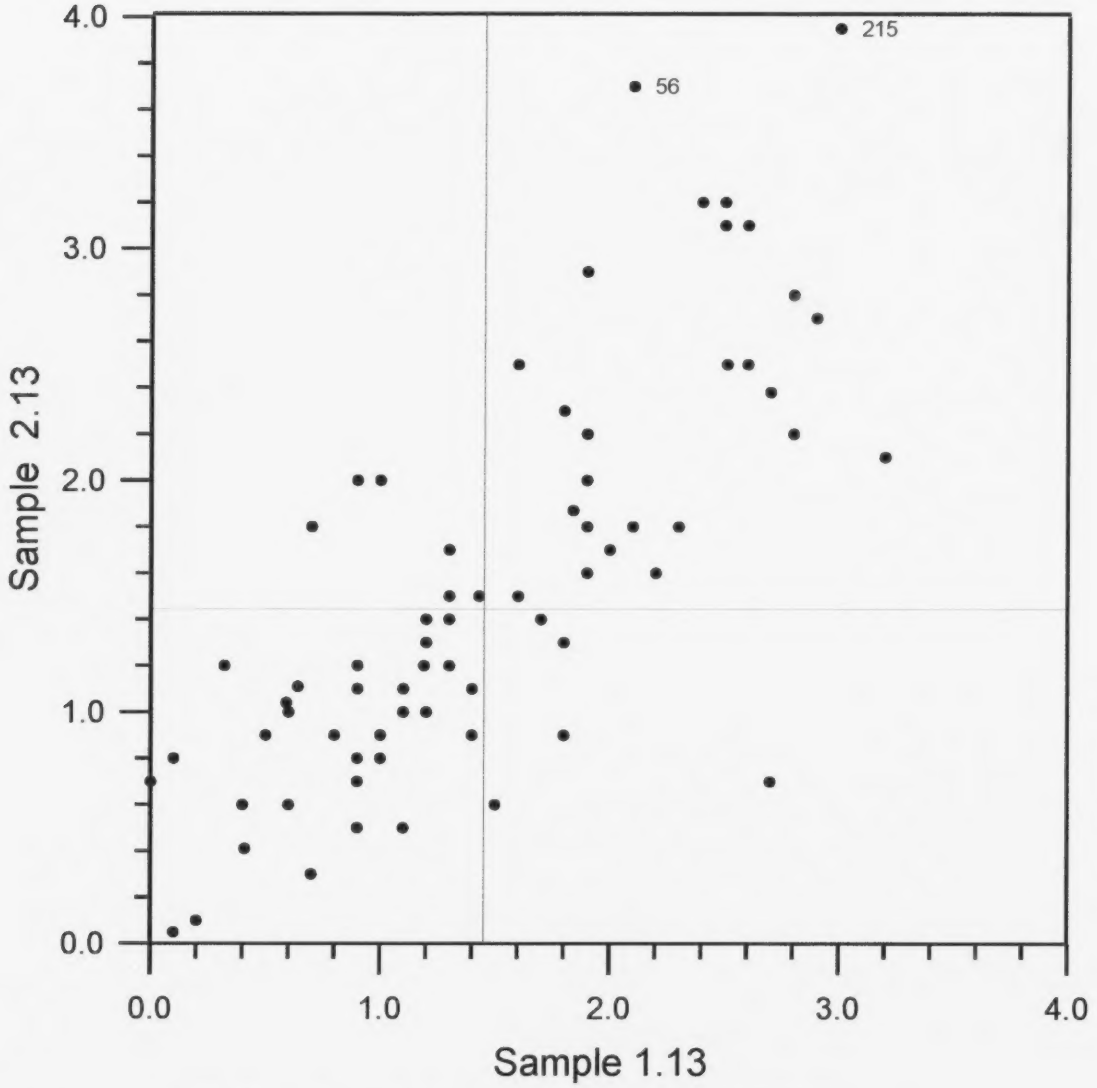
Test 97: Percent Fractured Particles

	Mat 1	Mat 2
Mean	71.443	71.453
Median	71.200	71.800
Std Dev	4.562	4.322

n = 72

Labs Eliminated: 13; 75

2013 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



Test 99: Percent Flat and Elongated Particles

	Mat 1	Mat 2
Mean	1.434	1.433
Median	1.600	1.625
Std Dev	0.804	0.780

n = 72

Labs Eliminated: 56; 215

Appendix E1: Petrographic Results of Coarse Aggregate

Laboratory Number		1	1	3	3	13	13	15	15	27	27	30	30
Sample Number	Type No.	1.13ST	2.13ST	1.13ST	2.13ST	1.13ST	2.13ST	1.13ST	2.13ST	1.13ST	2.13ST	1.13ST	2.13ST
Carbonate (hard; silty, hard)	1	10.2	6.5	54.3	66.6	34.7	31.3	21.6	18.8	82.5	75.5	63.3	55.7
Carbonate (surf. weath.; silty, surf. weath.; med. hard; silty, med.hard)	20	33.9	36.4	23.8	11.6	23.3	43.2	63.3	65.0	4.1	5.1	7.7	6.0
Carbonate (sandy, hard or medium hard)	2	21.4	25.9			12.5						8.6	11.8
Carbonate (slightly cherty: <5%)	21	6.2	1.6	7.4	7.9	19.9	10.9	1.6	2.3	4.1	5.0	5.2	8.5
Marble (hard or medium hard)	23												
Conglomerate-Sandstone-Arkose (hard)	3												
Gypsite (<10%)	77												
Carbonate (carbonaceous coral)												2.8	
Flint/Jasper	81												
Total Good Aggregate (%)		**71.67**	**70.34**	**85.5**	**86.1**	**90.64**	**85.42**	**86.5**	**86.1**	**90.7**	**85.6**	**87.7**	**82.0**
Carbonate (soft; silty, soft; slightly shaley)	35	7.8	10.2	0.2		7.2	7.4	3.8	1.8	0.6	2.5	2.2	2.6
Carbonate (soft, pitted)	41	3.3	1.7						0.4				0.1
Carbonate (deeply weathered; silty, deeply weathered)	42			2.0	0.8					0.9	0.8		
Carbonate (sandy, soft)	40	4.8	5.2									0.8	1.7
Chert-Cherty Carbonate (<20% leached chert)	26	1.8	5.2	8.5	7.8		7.0	8.3	10.1	7.4	10.6	4.7	6.1
Carbonate (carbonaceous coral)													0.7
Total Fair Aggregate (%)		**17.69**	**22.32**	**10.7**	**8.6**	**7.18**	**14.36**	**12.1**	**12.3**	**8.9**	**13.9**	**7.7**	**11.2**
Carbonate (shaley; clayey; silty, clayey)	43	0.5	1.0		0.1	0.7	0.2	0.2	0.1				4.3
Carbonate (ochreous; sandy, ochreous)	44		0.3			0.9						0.2	
Chert-Cherty Carbonate (>20% leached chert)	45	10.1	5.5	3.8	5.2	0.8		1.2	1.5	0.4	0.5	3.8	2.0
Siltstone	56												
Carbonate (coral)												0.6	0.5
Total poor Aggregate (%)		**10.55**	**6.84**	**3.8**	**5.3**	**2.38**	**0.22**	**1.4**	**1.6**	**0.4**	**0.5**	**4.6**	**6.8**
Ochre	60	0.1	0.5										
Shale	61												
Total Deleterious Aggregate (%)		**0.09**	**0.5**										
Reported total mass examined		1530.7	1501.2	1524.8	1572.3	1520.2	1499.1	1549.9	1552.6	nr	nr	1343.9	1312.4
Reported PN		**188.9**	**183.4**	**140**	**144**	**126.9**	**129.8**	**131**	**133**	**119.8**	**130.3**	**138.4**	**156.4**

nr = not reported

Laboratory Number Sample Number	Type No.	31 1.13ST	31 2.13ST	35 1.13ST	35 2.13ST	38 1.13ST	38 2.13ST	39 1.13ST	39 2.13ST	40 1.13ST	40 2.13ST	47 1.13ST	47 2.13ST
Carbonate (hard; silty, hard)	**1**	6.3	14.0	69.8	69.1	74.4	77.5	60.5	62.4	6.9	7.5	11.5	11.9
Carbonate (surf. weath.; silty, surf. weath.; med. hard; silty, med.hard)	**20**	77.1	67.0	5.2	5.4			26.2	23.7	66.0	67.4	60.8	65.9
Carbonate (sandy, hard or medium hard)	**2**												1.1
Carbonate (slightly cherty: <5%)	**21**	6.7	9.5	3.0	2.6	5.1	3.6	0.4	0.3	4.6	2.7	2.7	
Marble (hard or medium hard)	**23**												
Conglomerate-Sandstone-Arkose (hard)	**3**												
Gypsite (<10%)	**77**												
Carbonate (carbonaceous coral)													
Flint/Jasper	**81**												
Total Good Aggregate (%)		**90.1**	**90.5**	**78.0**	**77.1**	**79.5**	**81.1**	**87.1**	**86.4**	**77.5**	**77.6**	**75.1**	**79.0**
Carbonate (soft; silty, soft; slightly shaley)	**35**	7.3	8.6	4.0	4.2	2.5	1.4	3.9	3.9	0.7	1.7	3.0	3.6
Carbonate (soft, pitted)	**41**										1.0		
Carbonate (deeply weathered; silty, deeply weathered)	**42**												
Carbonate (sandy, soft)	**40**												
Chert-Cherty Carbonate (<20% leached chert)	**26**	1.7		18.0	18.7	15.0	13.4	7.9	8.4	2.9	2.6	1.7	1.5
Carbonate (carbonaceous coral)													
Total Fair Aggregate (%)		**9.0**	**8.6**	**22.0**	**22.9**	**17.5**	**14.8**	**11.8**	**12.2**	**3.6**	**5.3**	**4.7**	**5.1**
Carbonate (shaley; clayey; silty, clayey)	**43**	0.9	0.9							1.3		1.2	2.3
Carbonate (ochreous; sandy, ochreous)	**44**							1.1	1.4				
Chert-Cherty Carbonate (>20% leached chert)	**45**					2.6	4.2			17.6	17.1	18.6	13.6
Siltstone	**56**												
Carbonate (coral)													
Total poor Aggregate (%)		**0.9**	**0.9**			**2.6**	**4.2**	**1.1**	**1.4**	**18.9**	**17.1**	**19.8**	**15.9**
Ochre	**60**												
Shale	**61**											0.3	
Corals													
Total Deleterious Aggregate (%)												**0.3**	
Reported total mass examined		1506.1	1513.1	1504.2	1503.2	995.5	1000.3	1503.2	1503.7	1514	1522	1498	1494
Reported PN		**122.5**	**121.7**	**144**	**146**	**148**	**151**	**129.1**	**131.4**	**201.7**	**196.3**	**211.6**	**189.8**

nr = not reported

Laboratory Number Sample Number	Type No.	61 1.13ST	61 2.13ST	67 1.13ST	67 2.13ST	76 1.13ST	76 2.13ST	77 1.13ST	77 2.13ST	79 1.13ST	79 2.13ST	80 1.13ST	80 2.13ST
Carbonate (hard; silty, hard)	**1**	3.2	2.7	57.4	58.2	57.0	56.2	47.0	46.7	31.1	32.0	82.2	74.4
Carbonate (surf. weath.; silty, surf. weath.; med. hard; silty, med.hard)	**20**			20.3	20.4	21.2	21.0	20.1	20.2	42.7	46.0		
Carbonate (sandy, hard or medium hard)	**2**	92.1	92.0										
Carbonate (slightly cherty: <5%)	**21**			0.8	1.8	0.5	0.8	9.3	9.6	1.8	1.1	1.8	2.0
Marble (hard or medium hard)	**23**												
Conglomerate-Sandstone-Arkose (hard)	**3**	2.6	1.8										
Gypsite (<10%)	**77**							1.4	1.6				
Carbonate (carbonaceous coral)													
Flint/Jasper	**81**												
Total Good Aggregate (%)		**97.9**	**96.5**	**78.4**	**80.4**	**78.7**	**78.0**	**77.8**	**78.1**	**75.6**	**79.1**	**84.5**	**76.4**
Carbonate (soft; silty, soft; slightly shaley)	**35**	1.9	3.0	2.9	2.1	3.5	2.4	15.2	14.7	4.2	4.1	0.2	0.1
Carbonate (soft, pitted)	**41**									0.7	0.5		
Carbonate (deeply weathered; silty, deeply weathered)	**42**						0.2						
Carbonate (sandy, soft)	**40**	0.2	0.5										
Chert-Cherty Carbonate (<20% leached chert)	**26**			15.9	14.9	15.7	17.0	6.9	7.1	6.5	6.2	12.5	19.7
Carbonate (carbonaceous coral)													
Total Fair Aggregate (%)		**2.1**	**3.5**	**18.8**	**17.0**	**19.2**	**19.7**	**22.1**	**21.8**	**11.4**	**10.8**	**12.7**	**19.8**
Carbonate (shaley; clayey; silty, clayey)	**43**			1.1	0.7	0.6	0.4			0.4			
Carbonate (ochreous; sandy, ochreous)	**44**												
Chert-Cherty Carbonate (>20% leached chert)	**45**			1.7	1.9	1.5	1.9			12.6	10.1	2.7	3.7
Siltstone	**56**												
Carbonate (coral)													
Total poor Aggregate (%)				**2.8**	**2.6**	**2.1**	**2.3**			**13.0**	**10.1**	**2.7**	**3.7**
Ochre	**60**												
Shale	**61**												
Total Deleterious Aggregate (%)													
Reported total mass examined		1084.6	1063.3	1508	1510.1	1506.4	1503	1510.2	1517.7	1501	1504.9	1043.9	1071.5
Reported PN		**104**	**107**	**152**	**147**	**149**	**151**	**144**	**143**	**188**	**172**	**139**	**158**

nr = not reported

Laboratory Number Sample Number	Type No.	86 1.13ST	86 2.13ST	88 1.13ST	88 2.13ST	96 1.13ST	96 2.13ST	101 1.13ST	101 2.13ST	102 1.13ST	102 2.13ST	112 1.13ST	112 2.13ST
Carbonate (hard; silty, hard)	1	*51.0*	39.8	45.3	59.3	34.6	38.5	79.1	80.9	40.1	46.0		
Carbonate (surf. weath.; silty, surf. weath.; med. hard; silty, med.hard)	20	27.9	44.5	31.5	20.4	38.3	38.7	7.2	3.6	20.2	22.9	64.8	69.2
Carbonate (sandy, hard or medium hard)	2									26.0	17.4		
Carbonate (slightly cherty: <5%)	21		0.8	2.9	2.5	1.0	2.5	4.0	5.0	2.8	2.3		
Marble (hard or medium hard)	23												
Conglomerate-Sandstone-Arkose (hard)	3												
Gypsite (<10%)	77												
Carbonate (carbonaceous coral)													
Flint/Jasper	81									3.1	2.8		
Total Good Aggregate (%)		**78.9**	**85.0**	**79.7**	**82.2**	**73.9**	**79.7**	**90.3**	**89.5**	**93.1**	**86.1**	**64.8**	**69.2**
Carbonate (soft; silty, soft; slightly shaley)	35	7.1	4.7	4.9	3.5	6.0	2.7			0.7	0.5	25.7	18.9
Carbonate (soft, pitted)	41			0.3	0.07					0.4		0.9	1.8
Carbonate (deeply weathered; silty, deeply weathered)	42					1.7	1.6						
Carbonate (sandy, soft)	40												
Chert-Cherty Carbonate (<20% leached chert)	26	1.8	1.4	11.5	11.2	11.0	10.7	8.9	9.8	2.4	4.1	8.5	10.1
Carbonate (carbonaceous coral)													
Total Fair Aggregate (%)		**9.2**	**6.1**	**16.7**	**14.8**	**18.7**	**15.0**	**8.9**	**9.8**	**3.5**	**4.6**	**35.1**	**30.8**
Carbonate (shaley; clayey; silty, clayey)	43			0.3		0.6	0.2					0.2	
Carbonate (ochreous; sandy, ochreous)	44												
Chert-Cherty Carbonate (>20% leached chert)	45	11.7	8.7	3.4	3.0	6.8	5.1	0.8	0.7	3.3	4.1		
Siltstone	56	0.2											
Carbonate (coral)													
Total poor Aggregate (%)		**11.9**	**8.7**	**3.6**	**3.0**	**7.4**	**5.3**	**0.8**	**0.7**	**3.3**	**4.1**	**0.2**	
Ochre	60												
Shale	61		0.1										
Total Deleterious Aggregate (%)			**0.1**										
Reported total mass examined		1500.3	1506.5	1534.7	1534.6	1527.1	1533.3	1500.9	1500.9	1511.8	1497.1	1538.6	1511.8
Reported PN		**178**	**157**	**151**	**145**	**174**	**156**	**122**	**123**	**123.6**	**129.6**	**171**	**162**

nr = not reported

Laboratory Number Sample Number	Type No.	114 1.13ST	114 2.13ST	130 1.13ST	130 2.13ST	133 1.13ST	133 2.13ST	152 1.13ST	152 2.13ST	166 1.13ST	166 2.13ST	168 1.13ST	168 2.13ST
Carbonate (hard; silty, hard)	1	84.6	71.9	17.1	16.4	14.7	17.3	45.1	50.8	24.2	17.3	39.0	37.1
Carbonate (surf. weath.; silty, surf. weath.; med. hard; silty, med.hard)	20	5.8	14.2	62.5	66.2	72.2	66.8	32.6	32.9	56.5	63.8	27.8	32.4
Carbonate (sandy, hard or medium hard)	2												
Carbonate (slightly cherty: <5%)	21		2.8	3.2	3.5	1.8	4.2	2.7	3.0	3.6	2.0	8.8	4.0
Marble (hard or medium hard)	23												
Conglomerate-Sandstone-Arkose (hard)	3												
Gypsite (<10%)	77												
Carbonate (carbonaceous coral) Flint/Jasper	81												
Total Good Aggregate (%)		**90.4**	**88.9**	**82.8**	**86.1**	**88.7**	**88.3**	**80.4**	**86.7**	**84.4**	**83.1**	**75.6**	**73.5**
Carbonate (soft; silty, soft; slightly shaley)	35	6.1	10.1	4.7	1.1	1.0	0.6	1.0	1.3	1.7	1.4	7.4	6.8
Carbonate (soft, pitted)	41					0.3	0.2			0.2		1.4	3.3
Carbonate (deeply weathered; silty, deeply weathered)	42												
Carbonate (sandy, soft)	40												
Chert-Cherty Carbonate (<20% leached chert)	26	2.7	0.1	9.5	9.5	6.1	7.1	15.2	8.7	10.1	10.7	13.1	15.2
Carbonate (carbonaceous coral)													
Total Fair Aggregate (%)		**8.9**	**10.2**	**14.2**	**10.6**	**7.4**	**7.9**	**16.2**	**10.0**	**12.0**	**12.1**	**21.9**	**25.2**
Carbonate (shaley; clayey; silty, clayey)	43	0.7	0.8										
Carbonate (ochreous; sandy, ochreous)	44												
Chert-Cherty Carbonate (>20% leached chert)	45			3.0	3.3	3.9	3.8	3.4	3.3	3.6	4.8	2.1	1.0
Siltstone	56												
Carbonate (coral)													
Total poor Aggregate (%)		**0.7**	**0.8**	**3.0**	**3.3**	**3.9**	**3.8**	**3.4**	**3.3**	**3.6**	**4.8**	**2.1**	**1.0**
Ochre	60												
Shale	61											0.4	0.3
Total Deleterious Aggregate (%)												**0.4**	**0.3**
Reported total mass examined		1515.1	1518.4	1546.2	1585.1	1520.5	1523.2	1550.1	1531.6	1533.9	1528	1504.4	1513.4
Reported PN		**121**	**125**	**143**	**137**	**134**	**135**	**149**	**137**	**142**	**148**	**158**	**158**

nr = not reported

Laboratory Number Sample Number	Type No.	183 1.13ST	183 2.13ST	188 1.13ST	188 2.13ST	260 1.13ST	260 2.13ST	293 1.13ST	293 2.13ST	316 1.13ST	316 2.13ST
Carbonate (hard; silty, hard)	**1**	33.2	25.6	26.5	40.7	50.81	53.7	62.9	71.7	49.7	46.2
Carbonate (surf. weath.; silty, surf. weath.; med. hard; silty, med.hard)	**20**	55.5	63.4	46.1	34.9	29.14	28.32	11.9	9.3	32.4	31.9
Carbonate (sandy, hard or medium hard)	**2**	1.2	0.2					5.2	1.9		
Carbonate (slightly cherty: <5%)	**21**	2.1	2.7	2.1	6.6	1.0	0.22	0.3	0.7	1.7	5.0
Marble (hard or medium hard)	**23**	2.7	3.4								
Conglomerate-Sandstone-Arkose (hard)	**3**										
Gypsite (<10%)	**77**										
Carbonate (carbonaceous coral)											
Flint/Jasper	**81**										
Total Good Aggregate (%)		**94.52**	**95.39**	**74.7**	**82.2**	**80.95**	**82.24**	**80.3**	**83.6**	**83.8**	**83.1**
Carbonate (soft; silty, soft; slightly shaley)	**35**	2.8	1.6	2.4	3.6	0.82		5.7	2.9	1.9	2.1
Carbonate (soft, pitted)	**41**										0.3
Carbonate (deeply weathered; silty, deeply weathered)	**42**			2.5	4.0	3.25	1.47		1.1		
Carbonate (sandy, soft)	**40**	0.8						0.8	0.5		
Chert-Cherty Carbonate (<20% leached chert)	**26**	0.3	2.1	19.4	9.1	12.41	10.27	13.3	11.9	10.6	11.9
Carbonate (carbonaceous coral)											
Total Fair Aggregate (%)		**3.98**	**3.78**	**24.3**	**16.7**	**16.48**	**11.74**	**19.8**	**16.4**	**12.5**	**14.3**
Carbonate (shaley; clayey; silty, clayey)	**43**	0.4	0.2							0.8	0.6
Carbonate (ochreous; sandy, ochreous)	**44**		0.4								
Chert-Cherty Carbonate (>20% leached chert)	**45**	1.0	0.1	1.0	1.1	2.57	6.0			2.9	2.0
Siltstone	**56**										
Carbonate (coral)											
Total poor Aggregate (%)		**1.36**	**0.72**	**1.0**	**1.1**	**2.57**	**6.02**			**3.7**	**2.6**
Ochre	**60**										
Shale	**61**	0.13	0.1								
Total Deleterious Aggregate (%)		**0.13**	**0.1**								
Reported total mass examined		1487.3	1508.2	1535	1524.2	1000.5	1001.78	1526.2	1508.2	1062.2	1106.6
Reported PN		**116**	**112**	**153**	**139**	**146**	**154**	**139.4**	**132.8**	**143**	**142**

nr = not reported

Appendix E2: Petrographic Results of Fine Aggregate

Laboratory Number	3	3	15	15	27	27	35	35	47	47	79	79
Sample Number	**1.13**	**2.13**	**1.13**	**2.13**	**1.13**	**2.13**	**1.13**	**2.13**	**1.13**	**2.13**	**1.13**	**2.13**
Silicate (4.75-2.36 mm)	22.5	20.0	26.5	22.0	27.3	26.3	21.5	22.5	17.5	27.0	31.0	23.3
Silicate (2.36-1.18 mm)	24.0	28.5	24.5	22.5	24.0	27.7	20.5	22.5	27.5	31.5	39.7	35.3
Silicate (1.18-0.600 mm)	26.5	30.0	28.5	39.5	36.0	31.5	23.0	22.0	21.5	29.0	47.1	37.0
Silicate (0.600-0.300 mm)	37.5	49.0	45.5	55.0	50.7	41.3	35.5	35.5	37.0	42.0	54.0	48.6
Silicate (0.300-0.150 mm)	57.0	47.0	61.0	58.5	57.1	50.5	39.0	40.0	34.5	35.5	78.2	80.9
Silicate (0.150-0.075 mm)	79.0	37.5	80.5	81.0	62.9	60.2	47.5	46.0	30.0	31.0	80.4	71.2
Silicate (wt. avg. %)	**33.8**	**36.6**	**38.3**	**42.6**	**41.1**	**35.8**	**28.6**	**28.8**	**28.3**	**33.7**	**50.6**	**44.8**
Carbonate (4.75-2.36 mm)	67.0	60.0	65.0	68.0	68.3	70.7	71.5	72.0	71.0	66.5	65.0	67.5
Carbonate (2.36-1.18 mm)	68.5	60.5	68.0	69.5	74.2	66.4	73.0	70.0	63.5	56.0	56.1	59.3
Carbonate (1.18-0.600 mm)	68.0	59.5	65.5	56.0	61.5	63.1	72.0	70.5	68.5	63.0	49.5	56.3
Carbonate (0.600-0.300 mm)	60.0	47.0	49.0	42.5	37.9	52.7	60.5	60.5	58.5	55.0	42.3	45.7
Carbonate (0.300-0.150 mm)	41.0	52.0	35.5	35.0	37.9	47.1	59.5	57.5	62.5	63.5	16.4	15.8
Carbonate (0.150-0.075 mm)	20.0	62.0	15.0	13.5	35.1	36.8	51.0	53.0	67.0	68.5	14.0	23.5
Carbonate (wt. avg. %)	**61.2**	**55.1**	**55.7**	**52.0**	**55.8**	**59.2**	**66.7**	**65.7**	**64.3**	**60.1**	**45.3**	**49.5**
Shale (4.75-2.36 mm)			2.5	5.5	2.4	2.0	3.0	3.5	0.5	0.5	0.5	1.5
Shale (2.36-1.18 mm)	0.5		3.0	5.0	1.4	4.5	2.5	3.5	0.5	1.0	1.4	0.5
Shale (1.18-0.600 mm)			3.0	2.5	1.5	3.9	3.0	4.0	0.0	1.0	2.0	2.5
Shale (0.600-0.300 mm)			3.0	1.5	4.1	5.0	2.5	1.5	0.5	1.0	1.9	2.4
Shale (0.300-0.150 mm)			0.5	3.0	4.1	2.4	1.5	2.0	1.0		2.7	1.9
Shale (0.150-0.075 mm)				0.5	1.6	2.5	1.5	1.0			4.7	1.8
Shale (wt. avg. %)	**0.1**	**0.0**	**2.6**	**3.0**	**2.3**	**4.0**	**2.5**	**2.8**	**0.4**	**0.8**	**1.8**	**1.9**
Mica (4.75-2.36 mm)												
Mica (2.36-1.18 mm)												
Mica (1.18-0.600 mm)					0.5							
Mica (0.600-0.300 mm)				0.5	0.5	0.5						
Mica (0.300-0.150 mm)			1.0	2.5	0.5						0.9	0.5
Mica (0.150-0.075 mm)			0.5	3.5	0.4	0.5			2.0	0.5	0.5	0.4
Mica (wt. avg. %)	**0.0**	**0.0**	**0.1**	**0.5**	**0.4**	**0.1**	**0.0**	**0.0**	**0.1**	**0.0**	**0.1**	**0.1**
Chert (4.75-2.36 mm)	4.5	13.0	6.0	4.5	2.0	1.0	4.0	2.0	11.0	6.0	3.5	7.8
Chert (2.36-1.18 mm)	2.5	4.0	4.0	3.0	0.4	0.9	4.0	4.0	8.5	11.5	2.8	4.9
Chert (1.18-0.600 mm)	3.5	4.0	3.0	2.0		1.0	2.0	3.5	10.0	7.0	1.5	3.8
Chert (0.600-0.300 mm)	0.5	0.5	2.5	0.5		0.5	1.5	2.5	4.0	2.0	1.9	1.9
Chert (0.300-0.150 mm)			2.0	1.0				0.5	2.0	1.0	1.8	1.0
Chert (0.150-0.075 mm)	0.5		3.0	1.5					1.0		0.5	3.1
Chert (wt. avg. %)	**2.0**	**3.3**	**3.2**	**1.9**	**0.3**	**0.7**	**2.2**	**2.7**	**6.9**	**5.4**	**2.1**	**3.5**

Laboratory Number	**3**	**3**	**15**	**15**	**27**	**27**	**35**	**35**	**47**	**47**	**79**	**79**
Sample Number	**1.13**	**2.13**	**1.13**	**2.13**	**1.13**	**2.13**	**1.13**	**2.13**	**1.13**	**2.13**	**1.13**	**2.13**
Contamination (4.75-2.36 mm)												
Contamination (2.36-1.18 mm)			0.5									
Contamination (1.18-0.600 mm)												
Contamination (0.600-0.300 mm)												
Contamination (0.300-0.150 mm)												
Contamination (0.150-0.075 mm)			1.0									
Contamination (wt. avg. %)	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Cemented Particles (4.75-2.36 mm)	0.5											
Cemented Particles (2.36-1.18 mm)						0.5						
Cemented Particles (1.18-0.600 mm)					0.5	0.5						0.4
Cemented Particles (0.600-0.300 mm)												0.5
Cemented Particles (0.300-0.150 mm)					0.4							
Cemented Particles (0.150-0.075 mm)												
Cemented Particles (wt. avg. %)	**0.1**	**0.0**	**0.0**	**0.0**	**0.1**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**
Conglomerate, sandstone, quartzite (4.75-2.36 mm)	5.5	6.0										
Conglomerate, sandstone, quartzite (2.36-1.18 mm)	3.5	7.0										
Conglomerate, sandstone, quartzite (1.18-0.600 mm)	2.0	6.5										
Conglomerate, sandstone, quartzite (0.600-0.300 mm)	2.0	3.5										
Conglomerate, sandstone, quartzite (0.300-0.150 mm)	2.0	1.0										
Conglomerate, sandstone, quartzite (0.150-0.075 mm)	0.5	0.5										
Conglomerate, sandstone, quartzite (wt. avg. %)	**2.6**	**4.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Mudstone and Claystone (4.75-2.36 mm)		1.0										
Mudstone and Claystone(2.36-1.18 mm)	1.0											
Mudstone and Claystone (1.18-0.600 mm)												
Mudstone and Claystone (0.600-0.300 mm)												
Mudstone and Claystone (0.300-0.150 mm)												
Mudstone and Claystone (0.150-0.075 mm)												
Mudstone and Claystone (wt. avg. %)	**0.2**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Gradation (% retained)												
(4.75-2.36 mm)	11.4	10.7	9.5	10.9	9.3	11.4	11.7	11.6	12.4	11.6	11.2	11.3
(2.36-1.18 mm)	18.7	19.2	18.1	18.4	17.1	19.3	18.4	17.8	18	18	19.4	19.6
(1.18-0.600 mm)	25.1	25.6	26.7	26.1	25.9	26	26.1	26.8	26.3	28.3	26	25.6
(0.600-0.300 mm)	30.8	30.9	30.5	29.9	32.3	29.5	29.6	30	29.3	28.5	28.1	28.2
(0.300-0.150 mm)	11.6	11.4	12.1	11.7	12.3	10.8	11.4	11.1	11.1	10.7	12.1	12.3
(0.150-0.075 mm)	2.4	2.2	1.8	1.6	2.3	2.2	2	1.9	2	2.2	2.3	2.3
pass 75 µm	nr	nr	1.3	1.4	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.7
Total	100	100	100	100	100	100	100	100	99.9	100.1	100	100
total without pass 75	100	100	98.7	98.6	99.2	99.2	99.2	99.2	99.1	99.3	99.1	99.3

Laboratory Number	80	80	88	88	96	96	152	152	188	188	Average of
Sample Number	**1.13**	**2.13**	**1.13**	**2.13**	**1.13**	**2.13**	**1.13**	**2.13**	**1.13**	**2.13**	**Results**
Silicate (4.75-2.36 mm)	23.5	23.8	20.0	24.0	11.0	13.5	16.5	26.5	17.5	18.0	21.9
Silicate (2.36-1.18 mm)	25.6	29.6	23.1	39.0	6.0	16.0	34.5	38.5	28.5	22.0	26.9
Silicate (1.18-0.600 mm)	34.8	31.2	25.9	42.5	16.0	15.0	49.0	50.5	39.5	39.5	32.5
Silicate (0.600-0.300 mm)	47.1	49.8	58.0	45.0	31.0	37.5	56.5	58.5	42.5	54.0	46.0
Silicate (0.300-0.150 mm)	69.9	64.7	60.5	54.0	42.0	48.0	60.5	62.5	68.0	66.0	56.2
Silicate (0.150-0.075 mm)	58.9	64.5	49.0	56.0	56.0	60.0	69.5	65.5	73.5	77.0	60.8
Silicate (wt. avg. %)	**40.0**	**40.4**	**38.9**	**42.1**	**21.9**	**25.7**	**46.9**	**50.0**	**40.0**	**42.0**	**37.8**
Carbonate (4.75-2.36 mm)	63.8	65.8	68.5	61.0	76.0	74.5	71.0	63.0	72.5	72.0	68.2
Carbonate (2.36-1.18 mm)	68.8	60.6	61.3	42.5	82.5	73.0	52.5	52.5	58.0	64.5	63.7
Carbonate (1.18-0.600 mm)	60.4	64.7	64.2	36.0	77.0	75.0	40.0	42.5	52.0	52.0	59.9
Carbonate (0.600-0.300 mm)	52.4	47.8	36.0	44.0	62.0	54.5	33.0	36.5	50.5	41.5	48.6
Carbonate (0.300-0.150 mm)	30.1	33.8	37.0	36.5	53.0	50.5	31.0	30.5	30.0	30.5	40.3
Carbonate (0.150-0.075 mm)	40.1	34.6	45.0	32.5	41.0	36.0	26.5	29.0	24.0	22.5	35.9
Carbonate (wt. avg. %)	**56.0**	**54.7**	**52.0**	**42.5**	**69.8**	**65.4**	**42.2**	**42.9**	**51.8**	**50.4**	**55.4**
Shale (4.75-2.36 mm)	4.7	3.5			2.0	1.5			1.0	1.5	1.6
Shale (2.36-1.18 mm)	0.5	3.3	0.5	1.5	2.0			1.0	3.0	3.0	1.8
Shale (1.18-0.600 mm)	0.5	2.3	0.5	1.0	1.0	2.5	1.5	0.5	0.5	2.0	1.6
Shale (0.600-0.300 mm)	0.5	1.0		0.5	3.5	3.5	2.5	1.5	1.0	2.0	1.8
Shale (0.300-0.150 mm)		1.5	0.5	0.5	2.0	0.5	4.0	3.5	1.0	1.5	1.6
Shale (0.150-0.075 mm)	0.5	0.9	0.5	2.5	2.0	2.0	3.5	5.0	1.0	0.5	1.5
Shale (wt. avg. %)	**0.9**	**2.1**	**0.3**	**0.8**	**2.2**	**1.9**	**1.7**	**1.3**	**1.2**	**2.0**	**1.7**
Mica (4.75-2.36 mm)											0.0
Mica (2.36-1.18 mm)											0.0
Mica (1.18-0.600 mm)				1.0							0.1
Mica (0.600-0.300 mm)								0.5			0.1
Mica (0.300-0.150 mm)				4.5			0.5	1.0			0.5
Mica (0.150-0.075 mm)	0.5		5.0	5.5			0.5	0.5	1.0		1.0
Mica (wt. avg. %)	**0.0**	**0.0**	**0.1**	**0.9**	**0.0**		**0.1**	**0.3**	**0.0**	**0.0**	**0.1**
Chert (4.75-2.36 mm)	8.0	6.4	7.0	4.0	9.5	6.5	2.0	3.5	7.5	8.0	5.8
Chert (2.36-1.18 mm)	5.1	6.1	4.5	6.0	8.0	7.0	2.0	2.0	10.0	8.5	5.0
Chert (1.18-0.600 mm)	4.3	1.8	3.0	2.0	5.0	3.0		1.5	5.5	3.0	3.2
Chert (0.600-0.300 mm)		1.5	0.5	2.0	2.0	2.0			4.0	1.0	1.4
Chert (0.300-0.150 mm)				0.5	3.0	1.0			0.5	0.5	0.7
Chert (0.150-0.075 mm)				2.0	1.0	1.5					0.6
Chert (wt. avg. %)	**3.1**	**2.7**	**2.6**	**2.8**	**4.9**	**3.7**	**0.6**	**1.1**	**5.4**	**3.7**	**2.9**
Contamination (4.75-2.36 mm)											0.0
Contamination (2.36-1.18 mm)											0.0
Contamination (1.18-0.600 mm)											0.0
Contamination (0.600-0.300 mm)											0.0
Contamination (0.300-0.150 mm)											0.0
Contamination (0.150-0.075 mm)											0.0
Contamination (wt. avg. %)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Laboratory Number	**80**	**80**	**88**	**88**	**96**	**96**	**152**	**152**	**188**	**188**	**Average of**
Sample Number	**1.13**	**2.13**	**1.13**	**2.13**	**1.13**	**2.13**	**1.13**	**2.13**	**1.13**	**2.13**	**Results**
Cemented Particles (4.75-2.36 mm)		0.5									0.0
Cemented Particles (2.36-1.18 mm)		0.5							0.5		0.1
Cemented Particles (1.18-0.600 mm)											0.1
Cemented Particles (0.600-0.300 mm)											0.0
Cemented Particles (0.300-0.150 mm)											0.0
Cemented Particles (0.150-0.075 mm)											0.0
Cemented Particles (wt. avg. %)	**0.0**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**
Conglomerate, sandstone, quartzite (4.75-2.36 mm)			4.5	11.0	1.0	4.0	10.5	7.0	1.5	0.5	2.3
Conglomerate, sandstone, quartzite (2.36-1.18 mm)			10.6	11.0	1.5	4.0	11.0	6.0		2.0	2.6
Conglomerate, sandstone, quartzite (1.18-0.600 mm)			6.5	17.5	1.0	4.5	9.5	5.0	2.5	3.5	2.7
Conglomerate, sandstone, quartzite (0.600-0.300 mm)			5.5	8.5	1.5	2.5	8.0	3.0	2.0	1.5	1.7
Conglomerate, sandstone, quartzite (0.300-0.150 mm)			2.0	4.0			4.0	2.5	0.5	1.5	0.8
Conglomerate, sandstone, quartzite (0.150-0.075 mm)			0.5	3.5					0.5		0.3
Conglomerate, sandstone, quartzite (wt. avg. %)	**0.0**	**0.0**	**6.1**	**10.9**	**1.1**	**3.2**	**8.5**	**4.4**	**1.5**	**2.0**	**2.1**
Mudstone and Claystone (4.75-2.36 mm)											0.0
Mudstone and Claystone(2.36-1.18 mm)											0.0
Mudstone and Claystone (1.18-0.600 mm)											0.0
Mudstone and Claystone (0.600-0.300 mm)											0.0
Mudstone and Claystone (0.300-0.150 mm)											0.0
Mudstone and Claystone (0.150-0.075 mm)											0.0
Mudstone and Claystone (wt. avg. %)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Gradation (% retained)											
(4.75-2.36 mm)	12.5	11.5	10.9	11.2	12.1	12.2	11.3	10.6	11.7	11.2	11.3
(2.36-1.18 mm)	18	17.6	19.4	18.9	19	20.6	18.3	18.3	17.9	19.2	18.6
(1.18-0.600 mm)	26.5	26.7	25.7	25.5	24.9	26.1	24.6	25.7	25.4	25.7	26.0
(0.600-0.300 mm)	29.1	30.1	30.8	30.8	30.3	29.3	31.3	31.4	31.2	30.5	30.1
(0.300-0.150 mm)	11.8	12	11.1	11.3	11.3	9.9	11.9	11.6	11.5	11.1	11.5
(0.150-0.075 mm)	2.1	2.1	2.1	2.3	2.4	1.9	2.6	2.4	2.3	2.3	2.2
pass 75 µm	2.4	0.9	nr	nr	nr	nr	nr	nr	nr	nr	1.0
Total	102.4	100.9	100	100	100	100	100	100	100	100	
total without pass 75	100	100	100	100	100	100	100	100	100	100	

Appendix F1: Production Laboratory Ratings

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
2	3	27.5	2	10	10	75
4	8	28.6	10	8	10	92
8	10	28.9	10	10	9	97
9	10	18.5	10	10	9	82
12	10	30.0	10	10	10	100
13	8	14.7	10	9	10	74
15	10	25.4	10	10	10	93
16	8	20.2	7	0	0	50
17	7	25.6	10	9	9	87
18	10	28.4	9	0	10	82
19	10	28.9	10	9	10	97
20	9	29.2	10	10	10	97
21	3	29.2	6	10	10	83
22	10	30.0	10	10	10	100
23	0	25.4	10	9	8	75
25	10	25.4	10	9	10	92
26	10	28.4	10	10	10	98
27	10	26.5	10	10	10	95
28	5	28.4	10	10	10	91
29	9	26.7	10	10	10	94
30	10	25.9	10	7	10	90
31	6	24.5	10	10	7	82
32	5	28.9	10	10	9	90
33	10	28.9	9	10	10	97
34	10	27.5	8	10	10	94
35	10	30.0	10	10	10	100
36	8	28.4	8	4	5	76
37	8	29.5	10	10	10	96
38	9	21.5	9	9	9	82
39	9	25.1	9	9	10	89
42	5	17.2	10	7	10	70
43	10	26.2	3	10	10	85
44	10	29.7	9	9	10	97
45	9	28.6	8	9	2	81
46	10	21.3	10	10	10	88

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
47	10	24.5	10	8	9	88
52	4	17.5	8	10	8	68
54	10	25.1	10	9	10	92
56	8	25.6	10	10	6	85
58	10	29.5	10	10	9	98
59	10	27.5	10	10	10	96
60	10	28.9	0	0	4	61
61	10	25.6	10	10	10	94
62	9	29.5	10	8	9	94
63	10	13.1	10	10	10	76
64	10	26.5	8	4	7	79
65	8	26.7	10	9	9	90
68	10	28.4	10	10	10	98
69	5	17.2	10	10	10	75
70	7	28.9	9	10	6	87
71	8	28.4	8	9	10	91
72	7	25.6	7	9	10	84
73	10	25.9	3	2	7	68
74	9	27.8	10	7	4	83
75	8	24.8	6	7	8	77
76	10	30.0	10	7	10	96
77	3	9.3	10	10	10	60
79	9	29.7	10	8	9	94
80	9	25.1	10	7	9	86
81	7	30.0	6	10	10	90
83	8	27.3	9	9	10	90
85	8	30.0	10	9	10	96
86	7	25.6	9	10	10	88
89	9	25.4	10	9	4	82
90	10	23.5	10	0	8	74
93	10	26.5	10	10	10	95
97	10	27.8	10	6	10	91
98	5	27.3	8	10	4	78
99	9	27.3	10	9	6	88
100	9	29.7	10	10	10	98
101	9	27.5	10	10	10	95
102	10	24.0	10	5	10	84
103	6	27.3	10	10	10	90
107	10	22.6	10	6	10	84

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
108	10	28.1	9	10	10	96
110	9	23.5	10	5	10	82
112	7	23.5	0	9	9	69
113	10	28.1	10	10	10	97
114	9	27.5	10	10	10	95
115	10	29.5	10	9	10	98
116	3	28.1	8	10	10	84
117	9	28.6	6	10	10	91
118	8	24.8	4	10	7	77
119	10	24.8	9	10	10	91
120	10	27.8	9	9	8	91
121	10	29.2	10	10	10	99
122	10	27.0	8	9	9	90
124	10	25.4	6	8	10	85
126	10	26.5	9	10	10	94
127	10	27.5	10	10	5	89
128	10	14.7	6	9	9	70
129	10	20.7	1	10	9	72
137	10	13.4	9	10	10	75
138	10	27.8	10	10	10	97
139	8	25.9	7	8	10	84
141	10	29.5	10	10	10	99
143	10	25.4	9	10	9	91
144	8	28.9	8	8	10	90
146	9	29.7	4	10	10	90
147	8	25.4	10	9	10	89
149	8	22.6	8	9	9	81
151	10	28.9	9	9	9	94
154	10	28.9	10	10	10	98
156	0	29.2	5	10	9	76
157	10	14.7	10	8	10	75
158	6	27.8	10	9	9	88
159	10	28.6	8	10	10	95
160	9	22.9	10	8	10	86
161	6	29.5	9	2	7	76
163	10	27.0	10	8	9	91
164	8	28.4	9	10	10	93
167	10	20.7	9	9	7	80
168	10	25.4	10	10	10	93

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
169	9	30.0	7	9	9	**91**
170	2	18.8	10	9	7	**67**
171	10	21.0	8	10	4	**76**
172	9	15.8	9	9	9	**74**
175	10	29.2	10	6	8	**90**
176	0	19.6	0	7	10	**52**
177	8	28.6	10	10	10	**95**
178	10	20.2	10	10	10	**86**
179	9	23.7	9	8	10	**85**
180	10	24.3	9	9	9	**88**
181	0	29.7	9	9	9	**81**
182	5	28.4	9	0	10	**75**
183	10	27.3	10	0	5	**75**
184	6	25.1	9	10	10	**86**
186	10	18.3	10	9	9	**80**
187	10	27.5	5	10	9	**88**
188	8	28.4	10	9	10	**93**
193	10	30.0	10	9	10	**99**
194	0	28.4	8	7	10	**76**
195	0	30.0	10	9	10	**84**
196	5	29.2	10	6	9	**85**
198	10	28.1	10	8	10	**94**
199	6	30.0	10	10	10	**94**
200	10	27.3	6	10	10	**90**
205	10	27.3	10	0	10	**82**
208	10	24.8	0	8	0	**61**
210	10	29.7	6	10	10	**94**
214	10	29.7	10	0	7	**81**
216	8	28.1	10	9	10	**93**
217	10	29.7	10	10	10	**100**
218	0	27.8	7	0	9	**63**
219	0	24.3	9	2	10	**65**
232	9	25.9	10	6	9	**86**
234	6	23.7	10	10	10	**85**
235	6	24.8	10	2	10	**75**
236	9	27.3	3	10	10	**85**
245	10	28.4	8	9	7	**89**
248	9	16.6	7	9	10	**74**
249	9	19.9	8	8	6	**73**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
250	9	19.6	0	8	9	**65**
251	10	22.9	0	9	9	**73**
252	0	19.1	4	10	0	**47**
253	10	19.1	7	10	7	**76**
254	10	26.7	10	10	10	**95**
255	10	29.5	10	4	10	**91**
257	10	19.1	8	9	10	**80**
258	6	25.4	7	10	10	**83**
260	6	16.6	9	8	10	**71**
261	10	21.8	10	9	10	**87**
262	8	30.0	10	0	7	**79**
263	8	30.0	9	10	10	**96**
268	10	22.9	10	3	9	**78**
269	10	26.7	10	9	9	**92**
271	9	29.2	10	10	9	**96**
272	9	29.5	8	10	10	**95**
274	10	27.0	10	10	9	**94**
275	10	19.9	10	9	8	**81**
276	7	29.2	9	9	10	**92**
277	7	25.6	7	8	6	**77**
278	0	21.5	10	9	7	**68**
279	10	28.1	9	0	10	**82**
280	0	13.6	10	8	9	**58**
282	5	22.9	10	9	8	**78**
284	6	29.2	10	10	6	**87**
285	10	18.3	9	8	7	**75**
287	5	28.6	9	3	10	**79**
288	0	26.7	10	10	8	**78**
290	10	26.7	10	8	8	**90**
291	9	27.8	6	5	7	**78**
293	10	29.5	10	9	7	**94**
294	10	29.5	10	10	10	**99**
296	9	24.5	10	10	10	**91**
297	10	25.1	10	8	9	**89**
299	10	30.0	10	10	10	**100**
300	10	27.5	10	10	10	**96**
301	10	29.5	10	10	9	**98**
302	10	19.6	10	10	6	**79**
303	10	25.4	10	10	10	**93**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
305	10	26.7	8	7	9	**87**
307	10	27.5	9	10	9	**94**
308	10	27.5	10	10	8	**94**
309	10	29.5	8	10	8	**94**
310	9	28.4	10	8	10	**93**
311	10	28.1	8	9	9	**92**
312	8	24.5	10	10	10	**89**
313	10	29.2	10	5	10	**92**
314	10	20.5	10	10	4	**78**
315	2	27.8	0	10	7	**67**
316	10	21.3	10	10	10	**88**
318	10	26.5	8	7	10	**88**
320	10	23.7	9	6	10	**84**
321	9	26.2	8	10	7	**86**
322	9	14.2	1	10	6	**57**
323	10	24.8	8	10	10	**90**
324	10	27.8	10	4	10	**88**
325	9	27.0	10	10	9	**93**
326	10	23.5	1	10	8	**75**
327	9	28.9	10	10	10	**97**
328	10	30.0	10	10	10	**100**
329	4	28.1	9	10	5	**80**
331	10	28.6	8	10	0	**81**
332	7	21.5	10	*10*	10	**84**
333	0	26.5	10	*10*	10	**81**
335	9	28.6	3	*5*	9	**78**
337	10	25.4	9	*0*	7	**73**
339	10	29.2	10	*9*	8	**95**
340	8	28.6	5	*10*	10	**88**

Appendix F2: Full Service Aggregate Laboratory Ratings

FULL SERVICE AGGREGATE LABORATORY RATINGS 2013

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 $MgSO_4$ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-623 One-Point Proctor	LS-619 MDA (FA)	Rating
8	10	28.9		10.0	9	10	10	9	8	10	10.0	10.0	10	**96**
12	10	30.0		8.0	6	10	10	10	8	6	10.0	10.0	8	**90**
13	8	14.7		10.0	10	10	9	10	9	10	8.0	8.7	0	**77**
15	10	25.4		10.0	9	10	10	10	9	3	9.5	8.3	10	**89**
18	10	28.4		9.0	7	9	0	10	10	8	9.5	9.7	5	**83**
19	10	28.9	9	10.0		10	9	10	10	9	10.0	9.7	10	**97**
22	10	30.0		10.0		10	10	10	10	4	10.0	10.0	10	**95**
23	0	25.4		9.0		10	9	8	7	10	10.0	10.0	9	**83**
27	10	26.5	9	9.5	9	10	10	10	6	10	10.0	10.0	10	**93**
28	5	28.4		10.0		10	10	10	10	10	7.0	10.0	7	**90**
31	6	24.5	0	4.5	10	10	10	7	10	6	7.0	10.0	6	**74**
35	10	30.0	10	9.0	10	10	10	10	9	10	10.0	6.3	10	**96**
37	8	29.5		10.0	10	10	10	10	10	8	9.5	10.0	10	**96**
38	9	21.5	7	9.5	8	9	9	9	9	10	9.0	10.0	10	**87**
39	9	25.1		8.5		9	9	10	8	9	9.0	8.0	9	**87**
47	10	24.5	8	9.5	9	10	8	9	10	0	9.5	2.0	9	**79**
56	8	25.6	9	10.0	10	10	10	6	9	9	10.0	10.0	10	**91**
59	10	27.5		7.5	10	10	10	10	10	10	9.5	6.0	10	**93**
61	10	25.6		9.5		10	10	10	10	10	10.0	9.3	10	**96**
69	5	17.2		6.5		10	10	10	10	10	10.0	10.0	10	**84**
75	8	24.8		9.5	10	6	7	8	10	10	10.0	6.7	10	**86**
76	10	30.0		7.5	10	10	7	10	10	10	10.0		9	**95**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 $MgSO_4$ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-623 One-Point Proctor	LS-619 MDA (FA)	Rating
79	9	29.7		10.0		10	8	9	10	9	10.0	9.0	10	**95**
80	9	25.1	10	9.0	6	10	7	9	9	7	7.5	10.0	8	**84**
83	8	27.3		9.5	10	9	9	10	10	9	10.0	10.0	10	**94**
86	7	25.6		8.5		9	10	10	10	5	2.5	9.7	6	**79**
90	10	23.5		9.0	9	10	0	8	9		6		5	**75**
98	5	27.3		8.5	10	8	10	4	6	10	3.5	3.0	4	**71**
101	9	27.5	10	9.5	10	10	10	10	10	9	9.5	10.0	10	**96**
102	10	24.0		9.0		10	5	10	10	10	7.0	8.3	10	**87**
107	10	22.6		8.5	10	10	6	10	9	10	9.5		10	**89**
108	10	28.1		10.0	9	9	10	10	5		9.5	10.0	10	**93**
110	9	23.5		9.0	9	10	5	10	10	9	10.0	10.0	10	**89**
112	7	23.5		10.0	8	0	9	9	9	10	6.5	10.0	10	**80**
114	9	27.5		10.0	5	10	10	10	9	10	10.0	6.0	10	**90**
120	10	27.8		7.5		9	9	8	10	10	10.0	10.0	8	**92**
121	10	29.2		9.5	9	10	10	10	10	8	10.0	8.3	10	**96**
124	10	25.4		7.5		6	8	10	1	9	10.0	8.0	10	**81**
157	10	14.7		7.5	10	10	8	10	9	10	8.0		9	**82**
164	8	28.4		7.5	7	9	10	10	10	8	10.0		10	**91**
172	9	15.8		6.0	10	9	9	9	7	9	8.0	9.3	9	**79**
177	8	28.6		10.0		10	10	10	7	10	10.0		9	**94**
183	10	27.3		9.5	9	10	0	5	10	9	10.0	10.0	8	**84**
188	8	28.4	10	9.5	8	10	9	10	9	10	10.0	8.0	10	**93**
199	6	30.0		9.5		10	10	10	10	10	10.0	10.0	10	**97**
205	10	27.3		9.5		10	0	10	10	8	10.0	8.3	10	**87**
216	8	28.1		10.0	9	10	9	10	9	10	10.0	10.0	8	**94**
217	10	29.7		10.0	10	10	10	10	7		7.5		10	**95**
245	10	28.4		5.0		8	9	7	6	10	9.0	10.0	6	**83**
257	10	19.1		10.0	10	8	9	10	10	10	10.0	7.0	10	**88**
260	6	16.6		4.0	10	9	8	10	8	3	7.5	10.0	8	**72**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 $MgSO_4$ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-623 One-Point Proctor	LS-619 MDA (FA)	Rating
263	8	30.0		9.5	9	9	10	10	10	6	9.0	3.3	10	**88**
285	10	18.3		7.0	7	9	8	7	10	9	10.0	9.7	8	**81**
293	10	29.5		10.0	8	10	9	7	10	10	9.5	4.7	10	**91**
296	9	24.5		10.0		10	10	10	10	10	6.5	7.7	9	**90**
301	10	29.5		9.5	8	10	10	9	9	10	8.5	8.7	8	**93**
309	10	29.5		8.5	10	8	10	8	9	10	9.0	10.0	10	**94**
312	8	24.5		9.0	10	10	10	10	7	10	7.0	10.0	10	**90**
316	10	21.3		9.5	8	10	10	10	10	9	9.0	10.0	7	**88**
325	9	27.0		9.0		10	10	9	10	10	9.0	10.0	9	**94**
326	10	23.5		8.0		1	10	8	9	10	3.5	7.3	10	**77**
340	8	28.6		9.5		5	10	10	10	10	10.0		10	**93**

Appendix F3: Soil Laboratory Ratings

Lab No.	LS-702 Hydrometer Analysis	LS-703 & 4 Atterberg Limits	LS-705 Specific Gravity	Rating
8	7.0	10.0	10	90
9	7.6	10.0	10	92
12	8.6	8.0	0	55
13	4.0	9.3	6	64
15	9.6	9.3	10	96
18	9.8	9.7	8	92
19	7.4	9.7	9	87
20	9.6	10.0	10	99
21	8.6	8.7	0	58
22	10.0	10.0	10	100
23	9.4	6.7	0	54
27	9.8	7.7	10	92
28	8.4	9.0	10	91
29	9.8	9.3	10	97
30	9.6	6.3	8	80
31	8.8	9.7	10	95
32	10.0	9.3	10	98
35	9.6	10.0	10	99
37	9.8	9.3	8	90
38	9.8	9.7	8	92
44	9.4	8.3	10	92
46	9.0	6.7	9	82
47	5.2	8.7	9	76
52	9.8	3.7	0	45
54	6.8	7.3	10	80
56	8.2	10.0	10	94
58	9.6	10.0	10	99
59	10.0	10.0	10	100
62	9.6	10.0	10	99
63	9.8	8.0	9	89
64	9.0	3.3	9	71
68	10.0	10.0	10	100
69	9.8	8.3	5	77
71	9.2	10.0	9	94
72	9.6	10.0	10	99
74	9.0	10.0	9	93
79	9.0	9.3	10	94
80	9.6	10.0	9	95
81	7.6	8.3	10	86
83	9.6	10.0	9	95
86	8.0	7.7	7	76

Lab No.	LS-702 Hydrometer Analysis	LS-703 & 4 Atterberg Limits	LS-705 Specific Gravity	Rating
98	8.4	4.7	5	60
101	8.6	8.0	10	89
102	7.4	10.0	10	91
108	3.8	2.3	7	44
112	8.2	7.3	10	85
114	8.8	9.7	8	88
120	9.4	10.0	9	95
121	9.4	10.0	9	95
138	10.0	9.0	10	97
139	10.0	8.3	9	91
144	6.8	10.0	10	89
146	8.2	6.3	0	48
149	9.6	8.7	10	94
159	8.6	10.0	8	89
168	9.4	10.0	9	95
170	9.2	9.7	9	93
171	1.8	8.0	9	63
172	9.6	9.0	10	95
183	9.6	10.0	10	99
188	10.0	10.0	10	100
195	9.4	10.0	6	85
208	7.2	8.3	8	78
210	10.0	10.0	10	100
216	10.0	10.0	10	100
253	6.2	7.0	8	71
260	9.4	6.0	10	85
261	9.8	9.7	0	65
266	8.2	7.0	4	64
276	10.0	9.7	9	96
284	7.6	10.0	7	82
285	8.2	10.0	7	84
287	8.2	10.0	9	91
296	10.0	10.0	10	100
300	8.8	10.0	10	96
301	6.4	9.7	10	87
307	9.8	8.7	8	88
312	9.8	9.0	10	96
315	4.4	9.3	5	62
320	9.2	8.3	8	85
326	8.8	6.7	5	68

Appendix F4: Superpave Laboratory Ratings

Laboratory No.	C1252/T 304 Uncompacted Void Content	D2419/T 176 Sand Equivalent	ASTM D5821 % Fractured Particles	ASTM D4719 % Flat & Elongated	Rating
12	8	8	10	10	90
13	9	7	2	10	70
15	9	8	10	10	93
18	10	10	10	10	100
19	10	10	10	10	100
20	10	6	10	10	90
21	7	8	8	7	75
22	9	8	10	10	93
25	9	10	10	10	98
26	10	10	10	8	95
27	10	10	10	8	95
28	4	9	10	9	80
31	3	10	10	9	80
33	10	7	9	10	90
35	10	10	10	10	100
37	10	10	10	10	100
39	10	6	5	9	75
43	9	9	10	6	85
47	10	6	10	10	90
56	10	10	10	5	88
58	10	10	10	10	100
59	10	7	10	10	93
61	10	10	10	10	100
62	10	10	8	10	95
69	9	10	10	10	98
71	7	6	8	10	78
75	9	10	0	10	73
77	10	8	9	8	88
79	10	10	9	9	95
80	8	9	10	10	93
86	5	10	5	10	75
101	10	3	10	9	80
108	10	7	10	10	93
112	10	10	2	10	80
114	10	10	10	8	95
115	9	9	10	10	95

Laboratory No.	C1252/T 304 Uncompacted Void Content	D2419/T 176 Sand Equivalent	ASTM D5821 % Fractured Particles	ASTM D4719 % Flat & Elongated	Rating
120	10	10	10	10	100
121	10	6	10	10	90
124	10	9	9	10	95
157	6	10	9	10	88
172	0	7	6	9	55
180	10	9	10	6	88
181	9	8	10	6	83
182	10	10	10	9	98
183	10	8	10	9	93
188	10	6	10	10	90
193	10	10	10	8	95
199	10	10	10	10	100
215	2	10	5	3	50
216	10	8	10	8	90
217	6	10	8	10	85
236	7	10	7	10	85
245	9	10	10	8	93
253	10	10	7	10	93
255	9	10	9	9	93
257	10	10	4	6	75
263	10	10	8	8	90
271	9	9	10	6	85
272	8	10	10	8	90
285	10	10	10	9	98
293	10	10	6	8	85
296	10	10	10	10	100
300	10	10	10	10	100
312	10	10	10	10	100
316	9	10	4	7	75
325	10	10	9	6	88
326	6	10	10	6	80
340	10	10	9	9	95